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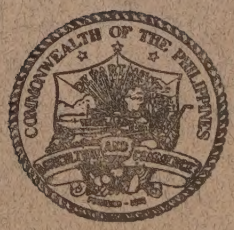

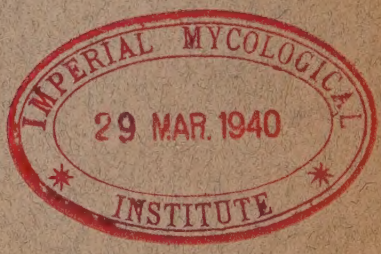

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The Philippine Journal of Agriculture

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COTTON PESTS IN THE PHILIPPINES [1]

By

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and

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THIRTEEN PLATES

In 1935, the writers published a preliminary paper on cotton insects in the Philippines with suggestions for their control. Since then additional data have been obtained which justify the publication of a bulletin in an effort to meet the demand for information on cotton pests and their control. This is deemed timely because of the encouragement being given to cotton growing with the object of supplying the ever-growing demand for the fiber for various local textile industries. Insect pests, in particular, constitute an important factor to contend with in cotton growing and cotton, being a dry season crop, its culture coincides with the abundance of some of the most important insect pests, particularly the local boll weevils, bollworms, plant lice, leaf hoppers and mealy bugs. The cotton planter should be familiar with at least the most important pests of cotton, their life histories and habits and the methods of preventing serious infestations by these pests.

In the control of cotton pests, every method possible should be employed. Along with the use of insecticides, the importance of mechanical methods of control, such as hand-picking,

[1] To be reprinted as Department Popular Bulletin No. 13.

should not be underestimated, especially in places where labor is cheap, for, when these methods are timely and persistently employed, the damage by certain pests, such as the boll weevil, can be greatly minimized. Due attention should also be given to the proper culture of the cotton plant, as this has much to do with the incidence of certain insects. Among the factors to be considered are the most suitable varieties or strains of cotton to plant, right time of planting, proper tillage and such other practices that will tend to conserve soil moisture, for lack of water makes the plants stunted and thus become susceptible to the attack of insects, particularly sucking insects.

BITING INSECTS

THE COTTON BOLL WEEVIL

(*Amorphoidea lata* Motsch.)

(Plate 1, figs. 3, 4, and 5)

Habits and descriptions.—This is probably the most destructive biting insect on cotton. Its work is similar to that of the notorious Mexican boll weevil (*Anthonomus grandis*) in the United States. The insect is dark brown and is from 3 to 4 millimeters long. As the name indicates, the insect is with a snout or beak at the end of which are the teeth and mandibles and other mouth parts.

At the Central Experiment Station, Singalong, Manila, the insects have been observed to gather in the newly opened flowers in the morning, usually between 7 and 10 o'clock, to feed and to breed. When ready to lay eggs, the female excavates a small cavity in the tissue of the base of the staminal sheath with its snout, and then reversing its position, deposits a single egg in this cavity (plate 1, fig. 1. See also plate 9, fig. 1). The eggs are smooth, pearly white, elliptical to ovoid, each measuring about 0.6 millimeter long and 0.4 millimeter in diameter. Several eggs may be deposited in a flower. An average of 5 eggs per flower has been found.

The larvae or grubs are wrinkled, grayish white, crescent-shaped, apodous or legless. A full-grown grub measures about 4 millimeters long and 1.2 millimeters at its greatest diameter. These larvae eat the ovules and other soft parts of the square. Because of this injury, the young bolls soon fall off to the ground (plate 1, fig. 2). As many as five larvae or grubs have been found in a fallen boll, which they soon leave to pupate in the

soil. The pupae are white, naked and resemble the adults as to form.

Life history.—Woodworth (1922) found out that the life history of the insect under conditions at the College of Agriculture, Los Baños, Laguna, was as follows:

Incubation period	1 to 3 days
Larval stage	5 to 9 days
Pupal stage	3 to 5 days

The life cycle, as given above, therefore, from the time the eggs were laid to the time the adult beetles emerged, was from 9 to 17 days, the average being 11.8 days.

The same author found out that the insect also bred in the flowers of a tree known in Tagalog as "makarapas" (*Thespesia lampas*) and that the beetles fed on the flowers of other plants related to cotton.

The life history of the insect as observed by the writers in the Entomology Laboratory in Manila are as follows:

Incubation period	2 to 3 days
Larval or grub stage	6 to 11 days
Pupal stage	2 to 5 days
Emergence to first laying of eggs	1 to 4 days

From the preceding data, the life cycle of the insect in Manila, from the time the eggs are laid to that when the adults begin to lay eggs, is from 11 to 23 days or an average of 17 days.

Control.—Since the full-grown grubs pupate in the soil, it is advisable that the fallen bolls be collected promptly every day and burned so as to prevent the pest from increasing rapidly.

Since the beetles congregate or gather in the newly opened flowers, as many as over thirty having been found in one flower, they should be collected and killed. If this is done persistently, especially when the early flowers appear, the damage can be greatly minimized.

The writers found out that dusting the beetles which congregated in the newly opened flowers in the morning with a 50–50 mixture, by volume, of calcium arsenate and "gaogao" killed the beetles in about half an hour. The same result was observed with derris powder mixed with an equal weight of "gaogao". These two insecticides may, therefore, be used especially on the early flowers that may be infested during the season. Dusting should be done at least three times a week, at about 10 o'clock in the morning so that the adults which sleep

in the older flowers have enough time to transfer to the newly opened flowers.

As to the natural enemies, only the bug (*Geocoris tricolor*, plate 10, fig. 5) has been found to prey on the weevils as well as on the mealy bugs (*Ferrisia virgata*).

THE BOLLWORMS

The caterpillars that attack the bolls of cotton, of which there are at least three species (Butac, 1938), are as important as the local cotton boll weevil. One of them, the pink bollworm (*Pectinophora gossypiella*), which is tropicopolitan, has been reported at one time, to be quite destructive in La Union. This is widely distributed in the Philippines, having been observed in the Ilocos provinces as well as in northern Mindanao by the writers. In other countries, as in Brazil, Egypt, and Mexico, the pink bollworm is known to be the worst pest of cotton, causing heavy losses in yield of both lint and seeds, amounting to millions of dollars. In the United States, the insect threatens to get established in the cotton belt. The United States Government spends hundreds of thousands of dollars annually for the quarantine and eradication of wild cotton (Hunter, 1918 and Curl, 1938). In the Coimbatore District, in south India, the pest is also said to be serious. In 1919, it was proclaimed, among others, as a pest under the Agricultural Pests and Diseases Act (Ballard, 1921). According to Wardle (1929) the pink bollworm disputes with the boll weevil (*Anthonomus grandis*) in America, the distinction of being the most destructive cotton pest in the world.

The two other species of bollworms (*Earias* spp.) otherwise known as "spiny bollworms" in Egypt, and "spotted bollworms" in India, certain species of which are found in the Philippines, are no less serious than the pink bollworms.

THE PINK BOLLWORMS

(*Pectinophora gossypiella* Saund.)

Injury and habits.—In the Entomology Laboratory at the Central Experiment Station, Manila, the female was observed to lay eggs during the night. The eggs were found laid on various parts of the plant as on the bolls, squares, flower buds and underneath the leaves when portions of the branches of the plant containing these parts were introduced into the breeding jar. Both sexes were inactive during the day. They were observed to hide most of the time between the lumps of soil at the bottom of the breeding jar.

The newly hatched larvae were observed to feed temporarily on buds or flowers and to transfer later to the bolls which provided abundant food for them (plate 3, fig. 3). They remained in the bolls to pupate. Before pupation they were observed to make exit holes through which they emerged when they became adults. Infested bolls matured abnormally and the lint was found to be short, colored, kinky, and weak and the seeds (plate 3, fig. 2) were of poor quality.

It was also observed that some of the larvae which were picked with the crop during harvest enclosed themselves by fastening together two hollowed seeds (plate 3, fig. 1). These were the larvae that would pass through a rest period or aestivation, the longest period observed so far in the Entomology Laboratory at the Central Experiment Station, Manila, being from 6 to 9 months. In Egypt, according to Gough (1921), a moth was found to emerge from double seeds received from India after two and one-half years. As was observed in Manila in 1935, larvae in cotton bolls were not destroyed during the ginning process. Therefore, when the seeds for the next planting season are stored, the larvae are stored with them, these emerging later as moths when conditions become favorable (Richard, 1924).

While some of the larvae of the later generations go to a state of aestivation, there are those that continue their life cycle by breeding on wild cotton and on the cotton plants left in the field. On several occasions during the off season for cotton in 1936, in the Central Experiment Station, Singalong, Manila, the junior author collected larvae and pupae of the insect from the cotton tree, *Gossypium arborium,* as well as from cotton plants left growing in the field during the time. So it can be readily seen that there are two sources of infestation for each year's crop, namely, from adults that emerge from larvae that aestivate, and from those that develop from volunteer plants and from those that are left in the field. Infestations may also come from growing perennial varieties of cotton plants.

Life history.—The life history of the insect as observed in the Entomology Laboratory in Manila was as follows:

Incubation period	4 to 6 days
Larval stage	14 to 25 days
Pupal stage	5 to 9 days
Emergence of adult to first oviposition	2 to 7 days

From the preceding data the life cycle in Manila, therefore, from the time the eggs were laid to that when the adults began to lay eggs was from 25 to 47 days, the mean being 30.9 days.

The period of fecundity varied from 6 to 10 days, with an average of 8 days. The average number of eggs laid daily by a female ranged from 3 to 74 or an average of around 27 eggs. The total number of eggs laid ranged from 194 to 234 eggs with an average of 219 eggs. Adults in confinement were found to live from 7 to 25 days or with an average of 14.8 days.

Description.—The following are the descriptions of the different stages:

The eggs (plate 2, fig. 2).—The eggs are small, elliptical, about 0.5 millimeter long and 0.3 millimeter in diameter, pearly white and are finely reticulated. About a day before hatching, the eggs turn faint orange with a distinct darker shade at one end, indicating the head of the developing embryo.

Larval stage (plate 2, fig. 3; also plate 9, fig. 5).—The newly hatched caterpillar is about 1 millimeter long, yellowish and with a dark brown head. As the larva grows, it becomes pink in color, hence the name, and the weak pale yellow hairs or setae scattered all over the body become more prominent. A full-grown larva measures about 1.2 centimeters long and 2.5 millimeters wide.

Pupal stage (plate 2, fig. 4; also plate 9, fig. 6).—The pupa is orange to reddish-brown in color turning conspicuously darker after about a day before the moth emerges. It is rather densely covered with setae, some of those at the caudal end being distinctly longer and larger and are hooked at the end. The length and diameter are about 9 and 3.8 millimeters, respectively.

Adult stage (plate 2, fig. 1; also plate 9, fig. 7).—The female moth is small and slender. It is about 7 millimeters long from the tip of the head to that of the abdomen and the wing expanse is about 15 millimeters. The color is gray to somewhat dark brown. The fore wings are rather acutely pointed and are fringed with setae along the apical margins. The hind wings are somewhat broader and are more acutely pointed than the fore wings. The sexes are similar in size and appearance.

THE "SPOTTED BOLLWORMS"

(*Earias fabia* Stoll.)

Injury and habits.—The adult insects are nocturnal. The female was observed to lay eggs during the night only, laying

these singly on or near the terminal buds, and sometimes on the bolls and flowers.

The larvae were observed to appear in the cotton fields before the plants were in bloom. At this stage of the growth of the plants the larvae bore into the stems and branches of the plants from the buds, thus destroying the main shoots and branches which potentially bore the flowers or bolls (plate 4, figs. 1 and 2). Between 9 and 12 o'clock in the morning they were observed to wander from one branch to another, as if in search of a suitable branch to bore into. When flower buds, flowers and bolls were already present, the caterpillars appeared to show a decided preference for these; hence, perhaps, the name "bollworm."

The caterpillars hollow out the flower bud or completely eat all the contents. If it is an open flower which is attacked they simply destroy the anther and then leave it in preference to the bolls. A very good indication of the presence of larvae in the bolls is the fresh excrement passed out through the entrance hole which may be seen projecting out from the side of an infested boll. The exit holes are located at the bases of the attacked bolls (plate 4, fig. 3). Once the larvae are inside the bolls, they destroy the seeds and incidentally damage the lint. When they are ready to pupate they come out of the boll to spin cocoon. It takes the larvae about a day to complete the work. During this period they cease to eat. The cocoons are attached to either the petioles and branches of the plant or to the bracts of the bolls.

Life history.—The life history of the insect as observed in the Entomology Laboratory in Manila was as follows:

Incubation period	2 to 4 days
Larval stage	11 to 17 days
Pupal stage	8 to 11 days
Emergence of adult to first oviposition	2 to 5 days

As shown above, the life history of the insect in Manila, from the time the eggs were laid to that when the adults began to lay eggs was from 23 to 37 days, the mean being 29.4 days.

The periods of fecundity varied from 8 to 22 days with an average of 13.3 days. The number of eggs laid daily by a female ranged from 1 to 73, with an average of 19 eggs. The total number of eggs laid ranged from 91 to 327 eggs, or an

average of 239 eggs. The adults were found to live from 3 to 28 days in confinement, or an average of 17.5 days.

Descriptions.—The descriptions of the different stages are as follows:

The eggs (plate 2, fig. 8).—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated, with projections or protuberances at one pole.

Larval stage (plate 2, fig. 6).—The newly hatched larva is about 2 millimeters long, the head being darker than the rest of the body, which is light brown. The full-grown larva is about 16 millimeters long, of a purple color, and the back is spotted with white. Because of these white spots the caterpillar has been called "the spotted bollworm," in India. Both lateral sides and portions of the back near the head and near the posterior end are tinged with orange. The dorsal and lateral sides of the larva are provided with short strong hairs or setae; hence the caterpillar is sometimes called "spiny bollworm."

Pupal stage (plate 2, fig. 7).—The cocoon which encloses the pupa is boat-shaped and the color varies from faint yellow to light brown. The cocoon is small, measuring about 9 millimeters long and about 4 millimeters at its greatest width. The anterior end of the cocoon is loosely woven, which condition facilitates the emergence of the adult.

Adult stage (plate 2, fig. 5).—The adult female is about 8 millimeters long from the tip of the head to the tip of the abdomen and the wing expanse is about 20 millimeters. The antennae are covered by the wings most of the time when the moth is in its natural resting position. The fore wings are pinkish-yellow, and each has a longitudinal triangular green streak in the middle, and is fringed with setae; head greenish-white, like the thorax, except the middle part, which is greenish. The palpi, antennae, legs and abdomen are yellowish. The adult male is about the size of the female and is of the same appearance.

Earias chromataria Wlk.

Injury and habits.—The adults (plate 2, fig. 9) are nocturnal. The female was observed to lay eggs singly on or near the terminal buds and sometimes on the bolls and flowers of cotton.

The caterpillars (plate 2, fig. 10) bore into the stems and branches of the young cotton plants from the buds. After they exhaust the soft portions they transfer to other shoots or

branches. But like the caterpillars of *E. fabia*, they show a decided preference for the flower buds, flowers and bolls.

The caterpillars hollow out the flower bud or completely eat all the contents. If they happen to attack an open flower, they simply destroy the anther. When caterpillars are inside the bolls they feed on the seeds and in so doing they also cut the lints. The presence of caterpillars in the bolls can be detected by the fresh excrement projecting out from the side of the bolls near the entrance hole. As soon as the larvae are ready to pupate they come out of the boll and begin to spin their cocoons, and this takes them a day to complete. The cocoons are attached to either the petioles and branches of the plant or to the bracts.

Life history.—The following records of the life history of the insect were taken in the Entomology Laboratory in Manila:

Incubation period	4 days
Larval stage	20 to 21 days
Pupal stage	7 to 12 days

The period, therefore, from the time the eggs were laid to that when the adults began to emerge, was from 31 to 37 days, the mean being 34.7 days.

Descriptions.—The following are the descriptions of the different stages:

The eggs.—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated and with projections or protuberances at one pole like those of the eggs of *E. fabia.*

Larval stage.—The newly hatched larva is about 2 millimeters long, the head being darker than the rest of the body, which is light brown. The full-grown larva is light gray, about 16 millimeters long and the back is spotted with dull white. The dorsal and lateral sides of the larva are provided with short strong hairs or setae like those of the larva of *E. fabia.*

The pupal stage.—The cocoon is boat-shaped like that of *E. fabia.* The color is light brown and is attached to either the petioles and branches of the plants or to the bracts. The cocoon measures about 9 millimeters long and about 4 millimeters at its great diameter.

Adult stage.—The adult female is about 7 millimeters long from the tip of the head to the tip of the abdomen. The wing expanse is about 17 millimeters. The fore wing is bluish-green with reddish-brown spots and is fringed with purplish-brown hairs. The base of the wing is reddish. The head is yellowish-

green and tinged with red and the bases of the antennae are reddish. The legs are white and also tinged with red. The male is about the size of the female and the color pattern is similar.

CONTROL MEASURE SUGGESTIONS FOR THE BOLLWORMS

Pink bollworm.—The bolls that mature early should be carefully examined and those found attacked should be gathered and fumigated with carbon bisulphide or with a mixture of ethylene dichloride and carbon tetrachloride.

The junior author observed in the barrios of Labagan, San Lorenzo, and Santa Rosa of San Nicolas, Ilocos Norte, that on the first and succeeding pickings (bucag) of matured bolls, the farmers separated the good floss from the seeds and bracts leaving the infested floss and seeds with the broken bracts, which were just thrown to the back yard near cotton fields. The full-grown larvae present in these discarded materials either go through a period of aestivation or pupate and become adults, and then fly to the fields thus increasing the infestation during the cotton season. Discarded floss and seeds should not, therefore, be carelessly thrown out but burned.

It is also suggested that after harvest, old plants and fallen bolls be destroyed by burning them. Volunteer plants during off season and alternate hosts, like the cotton tree, and other perennial varieties of cotton, especially those that are found near cotton fields, should be destroyed to prevent the insect from breeding there prior to the regular crop.

As most of the aestivating larvae are found in the fastened seeds, it is suggested that all seeds for planting be fumigated or dried well before storing them in tightly closed containers.

The suggestion of Fletcher (1917) to irrigate areas, which have been under cotton, may help reduce the number of larvae that go through a period of aestivation. The idea is that when the soil is irrigated while the temperature is high, many larvae resting in the ground are induced to abandon the resting stage, to come up to the surface, then pupate and emerge as moths long before they have a place to breed in, thus breaking their life cycle.

Spotted bollworms.—In the study on the life history and habits of the two spotted bollworms during the cotton season of 1935–1936, it was observed that infestations began during the latter part of December just before the beginning of the appearance of flower buds in January. From these observations, it would appear that cutting off the attacked shoots of cotton plants and

picking and destroying all the early bolls which show signs of infestation will tend to minimize the infestations.

After harvest, it is suggested that all cotton plants, including volunteer plants should be pulled out and burned so that there will be no source of food left for the insect in the cotton fields up to the next cotton season. Since *Hibiscus esculentus* (okra) is an alternate host of *Earias fabia*, as has been previously observed by Woodworth (1921), as well as wild Malvaceous plants (Dammerman, 1929), it would be advisable to destroy those that grow near or in cotton areas to prevent the insect from breeding before the cotton season. These two measures, otherwise known as clean-up measures, have proved a success in Egypt, where they have legislation requiring that all cotton plants, after harvest be pulled out and burned together with the alternate hosts, *H. esculentus* and *H. cannabinus* (Gough, 1919). Similar measures are also employed in India.

With regard to the use of insecticides, Deshpande and Nadkarny (1936) had made extensive tests with lead arsenate, Paris green, calcium arsenate and sodium silico-fluoride. When used as dust they have great possibilities of being useful in controlling the spotted bollworms. However, they observed, as did Folsom and Bondy (1930) with the use of calcium arsenate, that the use of both insecticides (calcium arsenate and sodium silico-fluoride) was followed by heavy infestations of the cotton aphid (*Aphis gossypii* Glover).

TESTS WITH DERRIS ON *EARIAS FABIA*

On March 2, 1936, 5 caterpillars of *Earias fabia* were dusted in the laboratory with a fifty-fifty mixture (by weight) of derris dust and "gaogao." The derris dust had a rotenone content of about 3 per cent. An hour after dusting, the caterpillars were observed paralyzed and all died in a day.

On March 24, 1936, the test was repeated on 10 caterpillars. It was also observed that the larvae were paralyzed an hour after dusting, and on the second day all were dead.

In connection with these tests, it may be of interest to include the following observations made in connection with a dusting that was made with derris-gaogao on cotton plants in one of the plots at the Philippine Carnival Exposition in 1936. The main purpose of dusting was to control the leaf-eating caterpillars, especially those of *Anomis* (*Cosmophila*) *erosa*, which were found abundant on cotton plants. The dusting was performed at about 9 o'clock in the morning. Between 2 and 3 o'clock in the afternoon the plants were examined and collec-

tion was made of the insects found, especially those affected by the treatment. The insects collected were the following: 96 caterpillars of *Anomis* (*Cosmophila*) *erosa,* all paralyzed and 61 of them died after 2 days; 5 caterpillars of *Earias fabia,* all paralyzed and all died after 2 days; 19 adults of the local cotton boll weevil, *Amorphoidea lata,* all dead and were collected from inside the corolla of the flowers; 4 adults of the cotton stainer, *Dysdercus megalopygus,* all dead; 9 ladybird beetles (predators), all dead; 4 hymenopterous insects, all dead and were collected from inside the corolla of the flowers; 16 larvae of *Prodenia litura,* all vigorous and none died.

The results of the tests in the Entomology Laboratory, Manila, and in the open with derris-gaogao indicate that the mixture bids fair to be an effective remedy not only for the larvae of *E. fabia,* but also for other insect enemies of cotton. Further tests are necessary with the object of finding out, among other things, the rate and cost of application per hectare.

NATURAL ENEMIES

The pupa of *E. fabia* and that of the pink bollworm were found to be attacked by a hymenopterous parasite belonging to the genus *Brachymeria.* The introduced egg parasite, *Trichogramma minutum,* was observed to readily parasitize the eggs of the two spotted bollworms in test tubes. Tests conducted showed that 30 females of *T. minutum* could parasitize about 500 eggs of *Earias fabia.* The efficacy of using *T. minutum,* however, in the field remains yet to be studied.

THE COTTON STEM WEEVILS

(*Pempheres affinis* Faust.)

Injury and habits.—The cotton plants are attacked by this pest even before they are in bloom (plate 5, fig. 1). The female adult lays eggs on the stem and upon hatching, the larva mines within the stem (plate 5, fig. 2) of the plant and causes the appearance of swellings or gall-like formations on the affected parts. The infested plants become stunted and may succumb if the injury is severe. The infested plants easily break down when there is a strong wind. Pupation takes place in a chamber within the stem prepared by the larva.

Observations on beetles confined in vials showed that the male adult was much more active than the female. It was also observed that mating took place several times during the day, particularly in the morning. Sometimes the male was on the female for even longer than five minutes.

Life history.—So far, there are no local data on the life history of the pest. However, in a paper on *Pempheres affinis* in the Madras Year Book, Madras Department of Agriculture for the year 1918, as referred to by Ballard (1922), the following are given as the average periods for the different stages in the life history of the insect:

Egg stage	10 days
Larval stage	35 days
Pupal stage	12 days
Adult	30 days

Descriptions.—The adult insect is about 3 millimeters long, and is dark gray. The male, as was observed by Ballard (1922), could be distinguished from the female by the presence of a spine above the coxal cavity of the foreleg. In the corresponding part of the female, only a tubercle is present.

A full-grown larva is wrinkled, yellowish brown, crescent shaped, legless and the mandibles are dark brown. It measures about 7 millimeters long and 1.5 millimeters wide.

The pupa is naked, yellowish and resembles the adults as to form and is about 3 millimeters long.

Control.—Prompt cutting off of the infested stems and burning them is suggested. If the attack is too advanced, the whole plant should be pulled out and burned to kill the larvae or pupae inside. Early collection of the adults is also recommended as it is possible to see them crawling on the stems during the day, especially in the morning.

THE LEAF-EATING CATERPILLARS

The Cotton Semi-Looper or "Abutilon Moth" (*Anomis erosa* Hubn.)

Injury and habits.—This green and semi-looper (plate 6, fig. 1) or measuring caterpillar has been found quite common on cotton as a leaf feeder (plate 6, fig. 3). Judging from its work, it is capable of causing great injury when present in abundance. The adult female moth lays her eggs singly on the lower surface of the leaves. Upon hatching, the tiny caterpillars feed on the lower surface of the leaves, leaving only the upper membrane or epidermis. After the first molt, however, the caterpillars consume the whole tissue. The full-grown larva when ready to pupate incloses itelf by folding a leaf at one side with its silk or thread.

This insect is also found in the United States where it is known as the "abutilon moth." There, the abutilon plant was found by Chittenden (1913) to be the insect's preferred host. This species is widely distributed in Asia.

Besides on cotton, the caterpillars have been observed to feed locally on the leaves of cowpeas. In Woodworth's host index (1921), okra is included as one of its hosts.

Life history.—The following records of the life history of the insect were obtained in the Entomology Laboratory at Singalong, Manila:

Egg stage or incubation period	2 to 3 days
Larval stage	2 to 16 days
Pupal stage	6 to 7 days

DESCRIPTION

The egg (plate 9, fig. 2).—The egg is somewhat circular in shape, about 0.6 millimeter in diameter, flattened, with ridges radiating from the center. They vary in color, from light green to bluish green, and can be seen with the naked eye after one has learned to recognize them on the leaves.

The larva or caterpillar.—The caterpillars molt four times, that is, there are five instars. When newly hatched the caterpillars are about a millimeter long and are pale yellow but they soon become light green after feeding and the color becomes more pronounced as they grow older. White parallel lines or markings run practically the whole length of their bodies. The full-grown caterpillar is about 4 centimeters long and 3.5 millimeters wide.

The pupa.—The pupa is dark brown measuring from 15 to 17 millimeters long and from 4 to 4.5 millimeters in diameter. At the end of the last segment are four spines, two of which are curved downward or ventrad. There are also four bristles which are distinctly longer than the spines and which are curved or rolled at the end (all of these are parts of the cremaster).

The adult.—The adult female is brownish yellow, about 1.2 centimeters long and has a wing expanse of about 3.8 centimeters. The male is of about the same size. The outer or front wings are with transverse, dark brown wavy lines, the apical or posterior half being darker and more so in the case of the male. There is a small faint white spot or mark near the front margin of each outer wing about one-third the distance from the base.

Control.—The cotton field should be gone over often and the caterpillars and pupa should be picked and crushed as both stages could be easily recognized. Dusting or spraying with either lead or calcium arsenate (preferably with the latter, as it is cheaper) may also be employed.

For dusting, calcium arsenate may be used alone or mixed with "gaogao" or ordinary inert lime in the proportion of 1 part of calcium arsenate to 5 to 10 parts by volume of the filler or carrier. Dusting can best be done early in the morning when there is dew and when there is no strong breeze.

For spraying, use from 1.5 to 4 grams of calcium arsenate per liter of water or 7 to 14 spoonfuls (levelful) for every petroleum canful (about 5 gallons) of water. Then stir thoroughly before, and occasionally, while spraying, to keep the calcium arsenate particles in uniform suspension. A bucket pump, provided with several meters of rubber hose and with a good nozzle that will deliver the spray in a fine mist, may be used.

Spraying with soap solution at the rate of 10 to 20 grams per liter of water (1/5 to 2/5 kilo per 5 gallons or one petroleum canful of water) has also been found effective, especially on the young caterpillars.

Derris-"gaogao" dust, mentioned in the control of the spotted bollworms, may be used for the same purpose.

Natural enemies.—A hymenopterous parasite (*Euplectrus manilae* Ashmead) has been found to attack the caterpillars. This tiny insect (see plate 6, fig. 1; also plate 10, figs. 1 to 4, inclusive) which is about a millimeter long, with the head and thorax black and the abdomen and legs and antennae pale yellow, lays its eggs on the back or sides of the caterpillars and the larvae feed on the hosts by sucking their juices. When full grown, they move to the underside of the dead hosts (which are almost all skin and fastened to the leaves with silken threads) and then pupate. This parasite is certainly of help in keeping the pest in check.

The egg parasite, *Trichogramma minutum* Riley (plate 8, fig. 6) introduced by Doctor Merino from the United States in March, 1934, has been found to attack the eggs of *Anomis* (*Cosmophila*) *erosa* in the laboratory, and liberations have been made in various places.

THE COTTON PYRALID LEAF ROLLER

(*Sylepta derogata* Fabr.)

Injury and habits.—Another caterpillar which has been found rather common on cotton is that of a pyralid moth, *Sylepta derogata* (plate 6, fig. 2). This is known to be a serious pest in India. The insect lays its eggs singly on the underside of the leaves like *Anomis erosa*. The first instar caterpillar feeds on

the lower surface of the leaves leaving the upper membrane intact. After the first molt the caterpillar begins to consume the whole tissue and to roll the leaves to enclose itself with its silky threadlike secretion. It then pupates. This habit of rolling itself makes the pest more difficult to control than *Anomis*.

Life history.—The life history of the pest as worked out in the Entomology Laboratory at Singalong, Manila, is as follows:

Egg stage	2 to 3 days
Larval stage	14 to 16 days
Pupal stage	6 to 7 days

Descriptions.—The following are the descriptions of the different stages:

The eggs (plate 9, fig. 3).—The eggs are elliptical, about 0.6 millimeter in diameter and are laid singly, as stated previously, on the lower surface of the leaves. They are pale yellow in color and are difficult to detect on the leaves without the aid of a lens.

The larva or caterpillar.—The caterpillar molts five times, that is, there are six instars. The newly hatched larva is about 2.6 millimeters long, transparent and pale green with a pale brown head. In the subsequent instars, the larva's head is brown. The dorsal portion of the prothorax is heavily chitinized and this chitinized area is brown like the head. The full-grown larva is about 2.2 centimeters long and about 3 millimeters in diameter.

The pupa.—The pupa is from 1 to 1.3 centimeters long and from 2.5 to 3 millimeters at its greatest width. It is brown, turning darker when the adult is about to emerge. At the posterior or anal end are eight stout bristles, like those of *Anomis*, which are also rolled or curved at the end.

The adult.—The adult is yellowish-white measuring from 2 to 2.3 centimeters across the wings. On both fore and hind wings are numerous brown transverse wavy lines. The male is slightly smaller than the female and has its posterior abdomen more pointed and somewhat longer than that of the female.

Control.—(1) Spraying with calcium arsenate as suggested for *Anomis erosa*. (2) Collecting the caterpillars. (3) Spraying with soap solution of the same strength as that for *Anomis* may also be practiced.

TORTRICID LEAF ROLLER

(*Homona phanaea* Meyrick)

Injury and habits.—Another common caterpillar, which has been found on cotton is the larva of a tortricid moth, *Homona*

phanaea (plate 6, fig. 4). The insect lays its eggs in masses on the upper surface of the leaves of the host plant and the eggs are arranged like scales. Like the larva of *Anomis* and *Sylepta*, the newly hatched caterpillar feeds on the under surface of the leaf, leaving the upper membrane. In the succeeding instars, however, the larva begins to roll the leaf and consume the whole tissue. Within this too, pupation takes place.

Life history.—The following is a record of the life history of the insect in the Entomology Laboratory at Singalong, Manila:

Egg stage or incubation period	5 days
Larval stage	17 to 18 days
Pupal stage	5 to 7 days

Descriptions.—The different stages in the life history of the insect are as follows:

The eggs (plate 9, fig. 4).—The eggs are small, flat, and elliptical, and are laid one overlapping the other. The entire egg mass, which may contain from 99 to 250 eggs, is flat, elongated and is very smooth and glossy. The eggs are yellowish along the periphery, while towards the center, they are translucent.

The larva or caterpillar.—The larva molts five times before attaining full size. The newly hatched larva is pale yellow with the head and thorax dark in color. As the larva grows the dark color of the head and of the dorsal portion of the prothorax turns shiny black. A full-grown larva measures 2.5 centimeters long and 0.3 centimeter wide.

The pupa.—The pupa is 7 to 10 millimeters long and from 2 to 3.5 millimeters wide. It is reddish brown. The dorsal surface of the abdominal segments has minute spines arranged across the segments in two rows, the anterior row being more developed than the posterior. The cremaster is also provided with bristles, but these are distinctly shorter than those of the pupae of *Anomis* and *Sylepta*. The bristles are likewise curved or rolled at the end.

The adult.—The adults are brownish-yellow. The male is much smaller than the female, being only about 8 millimeters long while the female is 12 millimeters. The male has a prominent "costal fold" of scales at the base of the front or costal margin of the fore wing. The wing patterns in both sexes are similar.

Control.—Essentially the same control measures given for *Sylepta* are suggested. Collecting the egg clusters is also suggested.

Hymenopterous parasites have also been reared from the larvae of *Sylepta* and *Homona* treated in this paper. These are of help in the control of the pest.

Liberations of *Trichogramma minutum* have been made in the field and the parasite has been reared from egg clusters of *Homona phanaea,* indicating that this introduced parasite shows promise of getting established here.

OTHER CATERPILLARS OBSERVED TO ATTACK COTTON BOLLS AND LEAVES

Heliothis armigera Hubn.—This pest is comomnly known as the corn ear worm, a cosmopolitan insect, which was found to attack cotton bolls, but the infestation at Singalong was found very negligible. Baltazar (1934) states, however, that the caterpillars are a serious pest in the Ilocos Provinces, feeding not only on the bolls but also on the flowers and squares.

Cotton leaf miner (*Lithocolletis triarcha* Meyrick, plate 9, fig. 8 and plate 11, fig. 1).—This has been found rather abundant in Singalong, Manila. As the name suggests, the flattened larvae feed inside the leaves causing blotches or mines which later dry up. Two parasites of this leaf miner have been identified as *Elasmus* sp., near *homonae* Fen., and *Sympiesis* sp. by Mr. Gahan of the U. S. Bureau of Entomology, which identifications were sent to us by Mr. Cushman of the same institution.

The collection of infested leaves and placing these in wire cages which will allow the parasites to escape and continue their beneficial work but will prevent the escape of the moths is suggested to minimize the attack.

SUCKING INSECTS AFFECTING COTTON

A number of sucking insects attack cotton, the most important being the common mealy bug (*Ferrisia virgata* Ckll.), the melon aphis (*Aphis gossypii*) and the leaf hopper (*Empoasca flavescens* Fabr.). Besides the mechanical injury done by these insects, and the loss of sap from the host plants, they also exude honeydew, which serves as a medium for the growth of sooty mold, and this interferes with the food-making function (photosynthesis) of the chlorophyll. Then there is the possibility that at least some of these sucking insects, the Oriental cotton stainer (*Dysdercus megalopygus*), for instance, and other allied species, may serve as carriers or vectors for the causal organisms or pathogens of such local diseases affecting cotton or that the punctures caused may facilitate the entrance of such pathogens. In connection with disease transmission by sucking insects of the family *Pyrrhocoridae,* the following from

H. P. Krug (1936) may be of interest (those in parenthesis ours):

> An account is given of preliminary studies of the insect transmitted internal boll disease of cotton, which in this State (S. Paulo, Brazil) is due to the following organisms, in order of importance: several species of bacteria, two members of the genus *Nematospora*, namely *N. gossypii* and *N. coryli*. Some species of yeasts, and *Penicillium* sp. were also found associated with the disease . . . . The type of infection most frequently met with is bacterial. The insects chiefly concerned in transmission are (a) various species of cotton stainers (*Dysdercus* spp.), (b) other sucking insects.

Mendes (1936) also says the following:

> In the cotton-growing regions of the state of S. Paulo, three species of "stainers" of the genus *Dysdercus* (*Pyrrhocoridae—Hem. Heter*) have been recorded attacking the bolls, and producing some damages to the fibres. The chief damage is the disease known as "Internal boll disease" or "Stigmatomycosis," transmitted by these insects.

The general effect of all these injuries, together with that of certain other associated causes, is the stunting of the plants thus producing very few or no bolls.

THE ORIENTAL COTTON STAINER

("Vacavacahan")
(*Dysdercus megalopygus* Bredd.)

Injury and habits.—The farmers are very familiar with this insect, including at least one allied species, so that both hardly need any descriptions here. The adults (plate 7, figs. 1 and 2), as well as the nymphs (plate 7, fig. 5), insert their proboscis into the different parts of the bolls and suck the juice or contents of the fruits and seeds. As a consequence of their method of feeding, they cause directly the staining of the fibers, inflicting mechanical injury to the bolls causing these to develop abnormally. They may also serve as vectors or carriers of local cotton diseases.

The female was observed in the laboratory to lay eggs in batches in the soil placed at the bottom of the battery jar used for breeding the insect (plate 7, figs. 3 and 4). The eggs are white and ovoid, each measuring about 0.8 millimeter long and 0.6 millimeter in diameter. It takes about an hour for a female to lay a batch of eggs. In the laboratory, the insects were reared on cotton and kapok seeds.

During off season for cotton, the insect subsists on the following hosts: okra (*Abelmoschus esculentus*), lumbang-bato (*Aleurites moluccana*), papaya (*Carica papaya*), kapok (*Ceiba*

pentandra), gumamela (*Hibiscus rosa-sinensis*), roselle (*H. sabdariffa*), colut-colutan (*Urena lobata*) and other related plants.

The nymphs molt four times or there are five instars. Mating was observed to take place from two to three days after the nymphs emerged into adults.

Life history.—The life history of the insect as worked out by the junior author in the Entomology Laboratory at Singalong, Manila, from March, 1937 to February, 1938, was as follows:

Incubation period	4 to 7 days
Nymphal stage	19 to 31 days
Emergence of adult to first oviposition	2 to 10 days

The life cycle of the insect from the time the eggs were laid to that when the adults began to lay eggs was from 25 to 48 days, the mean being 36.4 days.

Periods of fecundity were found to vary from 4 to 26 days with an average of about 13.0 days. A female may lay as many as six times during her lifetime. The number of eggs laid by a female at a time ranged from 41 to 84 or an average of around 69 eggs. The total number of eggs laid by a female may reach as many as 417. Adults in confinement were found to live around 23 days for the female and 29 days for the male.

THE COMMON MEALY BUG

(*Ferrisia virgata* Ckll.)

The mealy bug (plate 8, fig. 1), *Ferrisia* (*Pseudococcus*) *virgata* Ckll., is undoubtedly the most common mealy bug in the Philippines. It has been observed rather serious on cotton at Singalong, Manila, and in other places during the season. These insects are very prolific and in a relatively short time they practically cover the stems. They also attack the leaves (plate 11, fig. 2).

Superficially, it can be distinguished from other local mealy bugs by its having two prominent or conspicuous tail-like waxy fringes at the posterior or hind end of its body. Besides the powdery secretion covering especially the upper surface of its body, the insect also has numerous glossy threads or filaments with which the newly born young are concealed. The mature female is from 4 to 5.5 millimeters long. Examined under the miscroscope, the antennae are eight-segmented and the tarsal claws are without teeth or denticles.

Although this mealy bug has many enemies, three kinds of parasites having been reared, namely, *Leptomastix longipennis* Mercet, *Holanusomyia pulchripennis* Girault, and *Blepyrus insu-*

laris Ashmead, and is also preyed upon by lady beetles, among them being the common ladybird beetle, *Chilomenes sexmaculata*, and a species of *Scymnus* and aphis lions and the bug, *Geocoris tricolor*, it usually gains the upper hand during the dry season and causes considerable harm. The insect becomes full grown in about a month and begins to produce many young a few days thereafter.

Colonies of this mealy bug are attended by several species of ants, among them being the common red ground or fire ant, *Solenopsis geminata*.

THE MELON APHIDS

(*Aphis gossypii* Glov.)

The melon aphid, *Aphis gossypii* (plate 8, fig. 2), vies with the mealy bug (*Ferrisia virgata*) in destructiveness. It has been observed that it attacks the cotton plants very early and retards their growth, as the leaves are curled including the youngest ones (plate 12, fig. 1). At Singalong, Manila, two-week old cotton plants planted in October, 1934, were found badly infested by this species.

This insect is cosmopolitan and is very variable in color as well as in size. As is true with other plant lice, both winged and wingless mothers are present and both reproduce parthenogenetically, that is, without previous fertilization as is apparently true in the case of aphids in tropical and other warm climates, and of greenhouse aphids in temperate climates, as has been previously observed by Uichanco (1921 and 1924).

On bearing cotton plants that were somewhat heavily infested at Singalong, Manila, both in the field and in the greenhouse in November, 1934, most of the insects were lemon yellow in color and some were dull yellow with a greenish tinge and the adult insects were about a millimeter long and even somewhat less.

The melon aphid has also been locally observed abundant on the eggplant, melon, upo, cucumber and pechay and other cruciferous plants. Lady beetles, particularly *Chilomenes sexmaculata* (plate 10, fig. 6; see also plate 12, fig. 2), syrphid flies, aphis lions and certain hymenopterous parasites, apparently of the family Aphelinidae, have been found to prey on it. Parasitized aphids are black and thus can be easily distinguished from the live ones, which are mostly yellow in color.

Colonies of this aphid are also attended by the red ant (*Solenopsis geminata*) and other ants. Colonies of the red ant, in

particular, should be destroyed, preferably with the use of poisonous substances such as calcium cyanide and poisoned syrups, as they encourage the multiplication of the aphids.

LEAF HOPPERS

(*Empoasca flavescens* Fabr.)

The most common leaf hoppers on cotton are a small green species, *Empoasca flavescens* Fabr. (plate 8, fig. 3), measuring about 3 millimeters in length. Like the melon aphid and the common mealy bug (*Ferrisia virgata*), they become very numerous towards the end of the rainy season and cause serious harm to the cotton crop (plate 13, fig. 1). In 1926, the senior author observed that these leaf hoppers and the melon aphids and mites were chiefly responsible for the failure of an extensive cotton planting at Novaliches, Caloocan, Rizal.

The female deposits its eggs in the midribs of the cotton plants causing the injured spots to swell. Both the adults and the young are voracious feeders causing the leaves to wrinkle or curl up. They also attack eggplants and potatoes.

THRIPS

Two species have been observed on cotton causing the leaves to appear spotted or whitish. One of these (plate 8, fig. 5)—the bigger species (*Bussothrips claratibia* Moulton)—is black, about a millimeter long and the wings are black and white. The smaller one is pale yellow and is the more common in the field.

The onion thrip (*Thrips tabaci*) is also recorded on cotton but we are not certain as yet as to the identity of this and the pale yellow one just mentioned here.

A black bug about 4 millimeters long and which may be mistaken for an ant has been observed to prey on the thrips.

WHITE FLIES

(*Bemisia inconspicua* Quaintance)

The white fly (plate 8, fig. 4), which commonly attacks cabbage, also attacks cotton making the leaves appear sickly (plate 13, fig. 2). Under greenhouse conditions, it has been found very harmful, attacking not only cotton and cabbage, but also cauliflower, tobacco, tomato, and pechay. It has also been observed on roses and on certain other ornamental plants.

The adult insect is about a millimeter long and the body is yellow with snow white and opaque wings. The eggs are laid in groups on the lower surface of the host plants. The nymphs and pupae are preyed upon by a hymenopterous parasite and a ladybird beetle.

RED SPIDERS OR MITES

Red spiders (*Tetranychus sp.*) have been observed abundant on cotton especially during the dry season. The nature of their injury resembles that of thrips. The red spiders have also been found to attack beans and peas.

CERCOPIDS

A species of cercopid, *Machaerota ensifera* Burm., has also been observed on cotton. This feeds chiefly on the tender parts of the stems. It is not usually abundant, however, and may be considered as a minor pest. The insect is about 5 millimeters long, yellowish brown and has its scutellum reduced into a spine which is directed backward.

CONTROL MEASURES FOR THE SUCKING INSECTS ON COTTON

The cotton stainers.—As the nymphs and adults can be easily seen, they should be collected and killed either by crushing them with the fingers or placing them in a can with kerosene.

Spraying with soap solution at the rate of 15 grams of yellow powdered soap per liter of water (about 60 spoonfuls per can of water) was found effective in controlling *Dysdercus* infestation on kapok fruits in 1937 at the Singalong Experiment Station. Spraying was done with a compressed air spray pump, but a bucket pump may be employed for the purpose.

The use of derris-"gaogao," as mentioned in the control of spotted bollworms was found quite promising. The preparation should be dusted where a great number of adults is congregated.

As there are many alternate hosts, at least those near the cotton field should be destroyed.

The other sucking insects.—The cotton plants, soon after germination, are usually attacked by the mealy bugs and the aphids. The infestations are at first localized and the planter should go over the field often and examine the plants in order to control such initial infestations. Even crushing the insects with the fingers will help. They can best be destroyed, however, by spraying. The following formula for destroying aphids as well as certain other sucking insects on cotton (the thrips, white flies, the leaf hoppers) and the mites, dealt with in this paper, is suggested:

Soft yellow, laundry soap—5 to 10 grams per liter of water or approximately 1/10 to 7/10 of a kilo in one petroleum canful of water.

For the mealy bugs a stronger solution is necessary, to insure killing them. The amount of soft, yellow laundry soap should be doubled, that is, 10 to 20 grams per liter of water or ap-

proximately 1/5 to 2/5 of a kilo for every petroleum canful of water. The amount of soap may be increased if necessary.

Powdered soap, which is especially convenient for combating insects, is available in the market. It dissolves easily by vigorous stirring in a few minutes. This costs about ₱3.00 per 5-gallon can or about 12 kilos. Forty to sixty spoonfuls (levelful) for every petroleum canful of water have been found sufficient for killing plant lice, mealy bugs and other insects like thrips, white flies and their larvae. Mites are also killed by this solution.

In spraying against aphids, mealy bugs, and leaf hoppers, in particular, the spray should be directed to the under side of the leaves to be sure that the insects are thoroughly moistened with the solution.

OTHER INSECTS ON COTTON

The following insects have also been observed on cotton but were very few and may be considered of minor importance:

Sucking insects—

Dysdercus poecilus H. S.
Tectocoris lineola
Saissetia hemisphaerica
Nezara viridula
Drosicha townsendi
Ricania speculum
Dictyopara sp.

Biting insects—

Phaneroptera furcifera Stal.
Prodenia litura

The following are mentioned by Baltazar (1934) but have not been personally observed by the writers.

Sucking insects—

Helopeltis spp., said to be serious at the College of Agriculture, Los Baños, Laguna.
Antilochus nigripes (Specimens were collected by Mr. Toquero, also of the Plant Pest and Disease Control Division, from cotton in Ilocos Norte in 1931).

Biting insects—

Euproctis varians
Acontia intersepta

Dammerman (1929), in his book, entitled "The Agricultural Zoölogy of the Malay Archipelago", gives the following insects as feeding on cotton among other host plants and they are listed here for some of them, at least, occur in the Philippines:

Zeuzera coffeae Nietn.—The red coffee borer, the adult being a moth.
Collyris bonelli— a tiger beetle.
Aelopus (*Epacromia*) *tamulus* F.—a grasshopper. Recorded.
Glyphodes indica Saund.—a pyralid moth. The caterpillars attack cucurbitaceous plants in the Philippines.
Euproctes (*Porthesia*) *scintillans* Wlk.—a lymantriid caterpillar said to be a serious pest of castor plant in the Malay Peninsula.
Nisotra gemella Erichs.—a flea beetle 2.5 to 3.5 millimeters long. According to Reveche (1922), this insect feeds on okra, roselle, gumamela, colut-colutan, etc., but apparently he had not observed it on cotton.
Hypomeces squamosus F.—a weevil (Curculionidae).
Mylabris postulata Thunb.—a cantharid (Meloidae). The larvae are well known predators of locust eggs but the adults feed on the pollen of flowers, including those of cotton.
Oxycarenus lugubris Motsch.,—of the family Lygaeidae; commonly known as the black cotton bug; 3.5 to 4 millimeters long with yellowish white fore wings, the central part being brown. The insects suck the juice of the seeds. This is listed by Woodworth (1921).
Dacus ferrugineus F.—This is the mango fruit fly, the insect having been noticed in cotton bolls.
Lecanium (*Saissetia*) *nigrum* Nietn.—a scale insect.
Pinnaspis aspidistriae Sign.—a scale insect.
Pseudococcus citri Risso—a mealy bug, closely resembling *Pseudococcus lilacinus*, which is quite common in the Philippines.
Tetranychus coffeae Nietn. (*bioculatus* W. M.)—the red tea mite.

The following are also listed by Woodworth (1921) as feeding on cotton but have not been observed:

Hypolimnas masippus Linn.—a nymphalid.
Hippotion celerio Linn.—a sphinx moth.
Euxoa segetis Chiff.—a noctuid.
Oxycarenus hyalinipennis Costa—a bug (Lygaeidae).

Scale insects—

Hemichionaspis townsendi Ckll.
Pseudococcus filamentosus Ckll.
Saissetia nigra Nietn. (listed by Dammerman as *Lecanium* (*Saissetia*) *nigrum* Nietn.)
Homona menciana Walk.

In addition to these records, the following item from Espino (1920) about cotton pests reported by a Spanish investigator prior to American Occupation is of interest.

The insect enemies of cotton reported during the Spanish régime in these Islands are "grillo de los campos" (cricket), "la oruga gris de una mariposa" (*Noctua subterranea*) and "larva del *Melolontha vulgaris*."

The *Noctua subterranea* may be either one of the common noctuids, *Prodenia litura* or *Heliothis armigera* Hubn, which attack cotton, the larvae of which pupate in the soil. *Melolontha vulgaris* is a European species and is not recorded in the Philippines. It is most likely that the larva involved was that of the "toy-beetle," *Leucopholis irrorata* Chevr., the most destructive grub here which attacks the roots of many crops (Otanes, 1931) including possibly cotton. Should these and other grubs be found abundant on lands that are being prepared for cotton, they should be collected and killed. Certain other control measures, such as collecting the beetles and spraying their favorite food plants may be employed.

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LITERATURE CITED

1. Ballard, E.: Results of investigation of the bionomics of *Platyedra gossypiella* Saunders, in South India, together with some notes on *Earias insulana* and *E. fabia*. Report of the Proceedings of the Fourth Entomological Meeting held at Pusa, 7th to 12th Feb. (1921) pp. 70–83.
2. Ballard, E.: Further notes on *Pempheres affinis* Fst. (The cotton stem weevil). Memoirs of the Department of Agriculture in India 7 (1922) 243–255.
3. Baltazar, E. P.: Cotton culture. The Philippine Agriculturist 23 (1934) 267–285
4. Butac, F. L.: Notes on the life history and habits of the cotton bollworms in the Philippines with suggestions for their control. Phil. Jour. Agr. 9 (1938) 137–151.
5. Chittenden, F. H.: The Abutilon moth. U. S. Dept. Agr. Bull. 126 (1913).
6. Curl, L. F.: Pink bollworm control in Southern States. Jour. Econ. Entomology 31 (1938) 652–656.
7. Dammerman, K. W.: The Agricultural Zoölogy of the Malay Archipelago. 1929. Amsterdam: J. H. de Bussy, Ltd.
8. Deshpande, B. P. and N. T. Nadkarny.: The spotted bollworms of cotton (*Earias fabia* Stoll. and *Earias insulana* Boisd.) in South Gujarat, Bombay Presidency. The Imperial Council of Agricultural Research (1936).
9. Espino, R. B.: Cotton. Phil. Agr. Rev. 13 (1920) 186–210.
10. Fletcher, B. T.: Report of the Proceedings of the Second Entomological Meeting held at Pusa, 5th to 12th Feb. (1917) p. 114

11. Folsom, J. W. and F. F. Bondy.: Calcium arsenate dusting as a cause of aphid infestation. U. S. Dept. Agr. Cir. 116 (1930).
12. Gough, L. H.: Proceedings of the Third Entomological Meeting at Pusa, India (1919).
13. Gough, L. H.: The pink bollworm in Egypt. Agricultural Research Institute (Pusa) Bull. 106 (1921).
14. Hunter, W. D.: The pink bollworm with special reference to steps taken by the Department of Agriculture to prevent its establishment in the United States. U. S. Dept. Agr. Bull. 723 (1918).
15. Krug, H. P.: A podridao interne dos capulhos do algodoeiro no Estado de Sao Paulo. Instituto Agronomico de Campinas (1936) 7–17.
16. Mendes, T. O. L.: Os "manchadores" do algodao (*Dysdercus* spp.) no Estado de Sao Paulo. Instituto Agronomico de Campinas (1936) 1–21.
17. Otanes, F. Q.: Notes on cane grubs in Batangas and Occidental Negros. Phil. Jour. Agr. 2 (1931) 373–410. (See also Sugar News 13 (1932) No. 1).
18. Otanes, F. Q. and F. L. Butac.: A preliminary study of the insect pests of cotton in the Philippines with suggestions for their control. Phil. Jour. Agr. 6 (1935) 147–174.
19. Reveche, F. R.: Life history and habits of some common Philippine flea beetles. The Philippine Agriculturist 11 (1922) 29–48.
20. Richard, P. B.: The Control of Cotton Pests in North India 19 (1924) 563–573.
21. Uichanco, L. B.: Reproduction in the Aphididae with a consideration of the modifying influence of environmental factors. Psyche 28 (1921) 96–109.
22. Uichanco, L. B.: Studies on the embryogeny and postnatal development of the Aphididae, etc. Philip. Journ. Sci. 24 (1924) 143–247.
23. Wardle, R. A.: The Problems of Applied Entomology. 1929. New York: McGraw Hill Book Co.
24. Woodworth, H. E.: A host index of insects injurious to Philippine crops. The Philippine Agriculturist 10 (1921) 9–35. (See also 10, No. 7 and 11, No. 2).
25. Woodworth, H. E.: The Philippine cotton boll weevil. The Philippine Agriculturist 10 (1922) 75–81.

ILLUSTRATIONS

Plate 1

Fig. 1. A cotton flower showing where eggs of the local cotton boll weevil (*Amorphoidea lata*) are laid.
2. A fallen square due to the work of the grubs or caterpillars.
3. A grub, very much enlarged.
4. A pupa, very much enlarged.
5. An adult, very much enlarged.

Plate 2

Fig. 1. Adult of *Pectinophora gossypiella*, enlarged.
2. Eggs, very much enlarged.
3. Larva, back and side views, enlarged.
4. Pupa, enlarged.
5. Adult of *Earias fabia*, enlarged.
6. Larva of *E. fabia*, back and side views, enlarged.
7. Cocoons of *E. fabia*, enlarged.
8. Eggs of *E. fabia*, enlarged.
9. Adult of *E. chromataria*, enlarged.
10. Larva of *E. chromataria*, back and side views.

Plate 3

Fig. 1. Fastened seeds of cotton showing where larvae of *P. gossypiella* rest or aestivate. These seeds passed through the cotton gin with the larvae in them uncrushed. Lower photo shows the same seeds separated.
2. At left is an abnormally matured cotton boll due to the attack of the pink bollworm. At right, a normal boll.
3. Cotton bolls attacked by the pink bollworm.

Plate 4

Fig. 1. Portions of cotton shoots cut before the blooming stage showing injury by the larvae of *E. fabia*. A caterpillar is shown by an arrow.
2. Cotton plants with their shoots damaged by the larvae of *E. fabia*.
3. Cotton bolls and a flower bud showing the larvae and the exit holes of the adults of *E. fabia*.

Plate 5

Fig. 1. The cotton stem weevil (*Pempheres affinis* Faust.).
2. Portions of cotton stems showing injury by larvae of the cotton stem weevil.

PLATE 6

FIG. 1. The "Abutilon moth" (*Anomis erosa* Hubn.): Adult moths, larvae and pupae, parasitized caterpillar and parasites (see also plate 10, fig. 1 for the parasites, enlarged).
2. The cotton pyralid leaf roller (*Sylepta derogata* Fabr.): Adult moth, caterpillars and pupae.
3. Caterpillars of *A. erosa* on cotton leaves showing nature of damage.
4. Tortricid leaf roller (*Homona phanaea*): Female and male moths, caterpillars and pupae.

PLATE 7

FIG. 1. Adult female of the cotton stainer, enlarged.
2. Adult male, enlarged
3. Eggs, greatly enlarged.
4. A bunch of eggs laid in a breeding jar. Note how the eggs are covered by the adult female after laying.
5. The different nymphal stages.

PLATE 8

FIG. 1. A mealy bug (*Ferrisia virgata*), enlarged.
2. A wingless female of the melon aphis (*Aphis gossypii*), enlarged.
3. A leaf hopper (*Empoasca flavescens*), enlarged.
4. White flies (*Bemisia inconspicua* Quaintance), enlarged.
5. One of the thrips (*Bussothrips claratibia* Moulton) on cotton, enlarged.
6. The egg parasite, *Trichogramma minutum.* (This introduced parasite has given indications of becoming established, having been reared from the eggs of *Homona phanaea,* and a nymphalid butterfly).

PLATE 9

FIG. 1. Egg of the cotton boll weevil (*Amorphoidea lata*), enlarged
2. Egg of *Anomis erosa,* enlarged.
3. Eggs of *Sylepta derogata,* enlarged.
4. Egg mass of the Tortricid leaf roller, *Homona phanaea,* enlarged.
5. 6 and 7. Caterpillar, pupa, and adult, respectively of the pink bollworm (*Pectinophora gossypiella*), enlarged.
8. Adult of the cotton leaf miner (*Lithocolletis triarcha*), enlarged.

PLATE 10

FIG. 1. A parasite (*Euplectrus manilae* Ashmead) of the caterpillar of the "Abutilon moth," greatly enlarged.
2. A caterpillar of same moth showing eggs of the parasite, as indicated by arrows.
3. A parasitized caterpillar. The larvae of the parasites are shown underneath the caterpillar and had fastened the dead caterpillar to a leaf by means of their silken saliva, enlarged.
4. A full-grown larva of the parasite, enlarged.
5. A bug (*Geocoris tricolor*), a predator of the adult cotton boll weevil (*Amorphoidea lata*) and certain other insects, enlarged.
6. Adult ladybird beetle (*Chilomenes sexmaculata*), a plant lice predator, enlarged.
7. Another ladybird beetle, enlarged.

PLATE 11

FIG. 1. Cotton leaves showing injury by the cotton leaf miner, indicated by the arrows.

2. A leaf and a portion of the stem of cotton showing mealy bug (*Ferrisia virgata* Ckll.) infestation. See also plate 8, fig. 1.

PLATE 12

FIG. 1. Cotton leaves showing melon aphids (*Aphis gossypii*). See also plate 8, fig. 2.

2. Cotton leaves at left showing melon aphids (*Aphis gossypii*): Eggs (on A), larva and pupa (on B) and adults of the ladybird beetle, *Chilomenes sexmaculata* (C) which is predatory on the aphids.

PLATE 13

FIG. 1. A cotton tree showing nature of injury by the leaf hoppers (*Empoasca flavescens*). Note the curled-up leaves. Aphids and mealy bugs were also found on the plant, thus contributing to the injury.

2. Cotton leaves showing larvae and pupae of the white fly (*Bemisia inconspicua*). Adults are also shown. See plate 8, fig. 4, which shows how the adult white flies look like.

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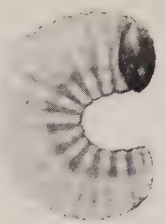

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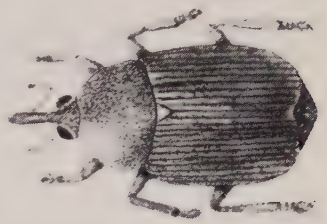

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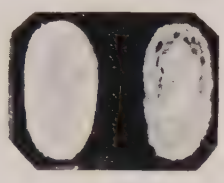

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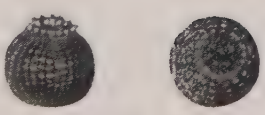

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PLATE 2.

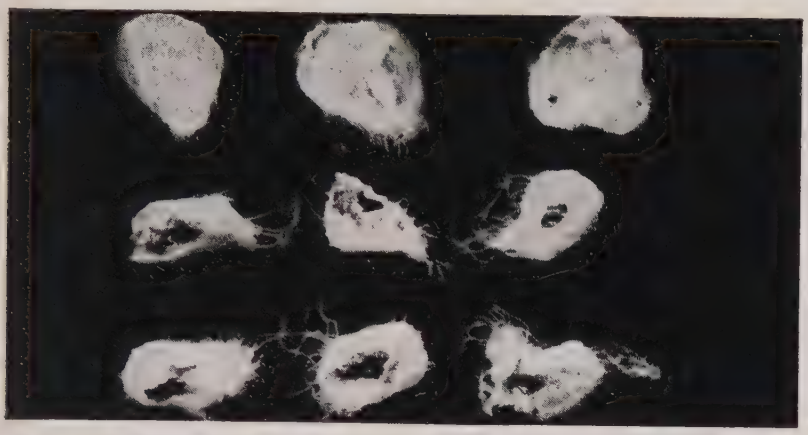

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PLATE 3.

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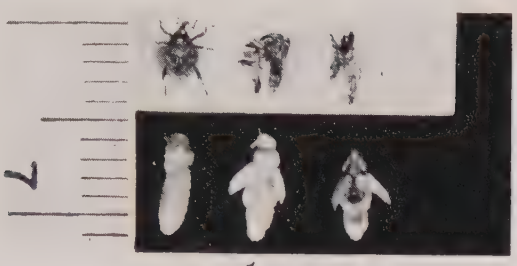

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PLATE 5.

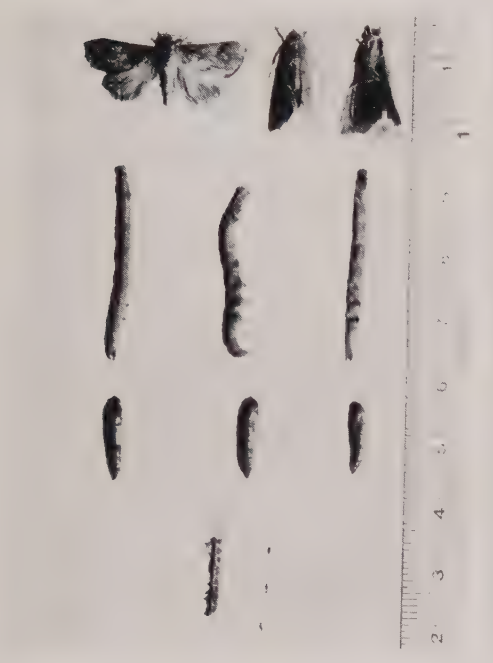

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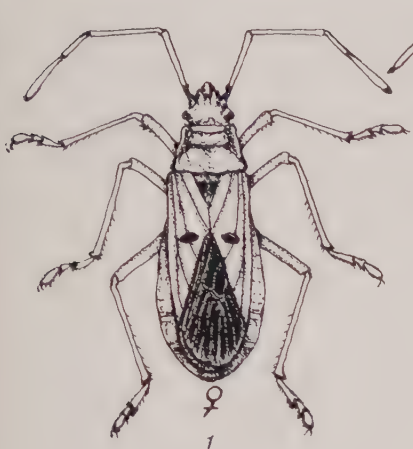
PLATE 6.



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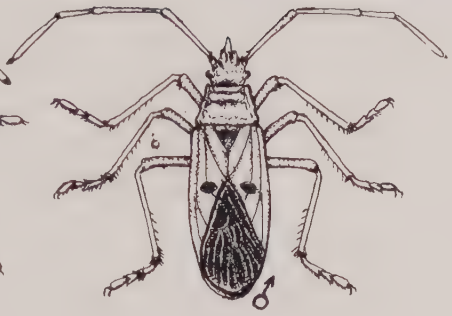

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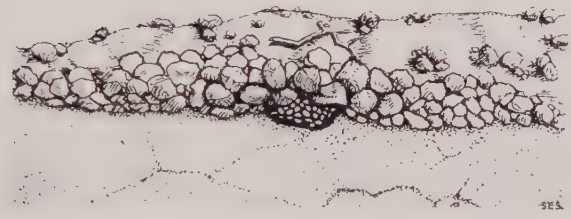

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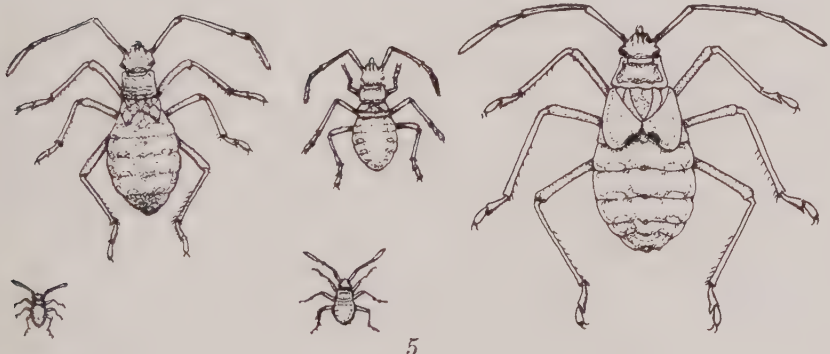

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PLATE 7.

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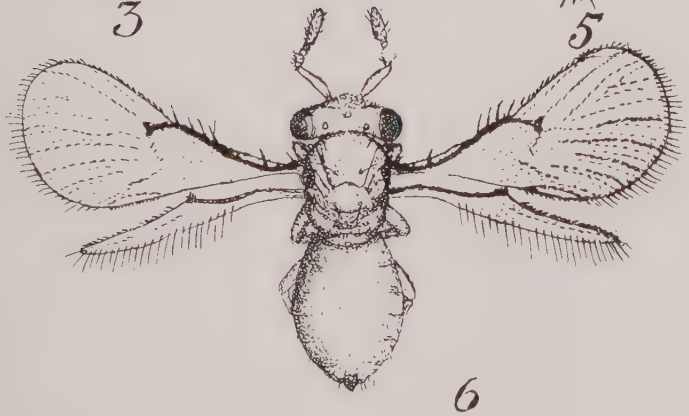

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PLATE 8.

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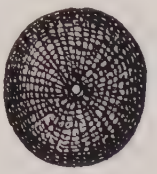

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PLATE 9.

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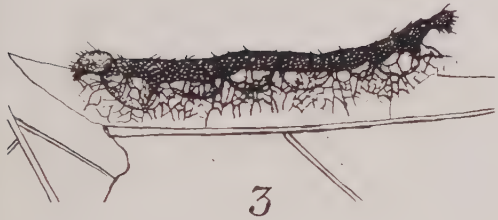

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PLATE 10.

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PLATE 11.

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PLATE 12.

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PLATE 13.

THE BACTERIAL WILT OF THE ABACÁ (MANILA HEMP) PLANT IN DAVAO: I. NATURE OF THE DISEASE AND PATHOGENICITY TESTS[1]

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Of the Bureau of Plant Industry

FIFTEEN PLATES

An abacá disease, which was recently reported as "abacá wilt"(5), "vascular disease"(1) and "banana-wilt-like disease" (2) is now considered to be the most serious of all the abacá maladies found in Davao, Mindanao. Other abacá diseases of major economic importance in Davao are the bunchy-top, the most notorious abacá ailment which holds an evil record of having reduced to almost extinction the once-flourishing abacá industry in the provinces of Cavite, Laguna, Mindoro, and Batangas, and the mosaic whose rapid spread has somehow affected the industry. A severe outbreak of any of these major diseases in a plantation means a direct financial loss to the planter since it entails a total destruction of the plantation. But among these major troubles of abacá, the wilt disease has recently caused much alarm in Davao owing perhaps to its extreme destructiveness. Ocfemia(2) (5) attributes the disease to *Fusarium oxysporum* Schlt. f. 3 Wr. = *Fusarium cubense* E. F. S., a prolific fungus well known to be the cause of a widespread banana disease known as Panama disease or banana wilt(6), while Calinisan(1) observes the association of both bacteria and *Fusarium* with the abacá plants affected by the disease. The findings of these two investigators have also called attention to the probable complex nature of the abacá wilt in Davao and have hinted on the difficulties which may be encountered in investigating this disease. Ocfemia(2) (3) (4), for instance, observes that the disease is complicated by the attack of a stem weevil (*Odoiporus paganus* Uichanco) while Calinisan(1) seems to insinuate that it may not be improbable that vascular wilt disease of both bacterial and fungal origin may occur in the same plantation or in the same plant at the same time.

Owing to the rapid spread of this disease which has caused no little alarm in Davao City in 1937, and in view of the vague-

[1] Read at the Fifth Philippine Science Convention held on February 22, 1939.

ness and inadequateness of present knowledge about its real nature and its causal relations, Dr. F. M. Clara, chief, Plant Pathology Section, Bureau of Plant Industry, suggested a renewal of the investigation on this disease assigning the senior author to undertake the work. In the present paper the disease is called "bacterial wilt of abacá" since the results of the present investigation show that it is due principally to a species of bacteria as will be discussed partly in this report and in succeeding reports.

OCCURRENCE

The first published report on the occurrence of the wilt disease of abacá in Davao was made in 1937 by Ocfemia,(2) (3) (4) who observed the similarity of the disease to the banana wilt caused by the fungus *Fusarium oxysporum*. The surrounding circumstances in which the disease commenced its depredations are now impossible to trace with certainty. However, there seems to be a close agreement in the information given by some abacá planters that the disease was first noticed in 1931 at Upper Bayabas, Guianga District, 3,000 to 3,600 feet above sea level. Whether this place served as the focus of infection for all of the places that were discovered later, nobody could tell. The probability is, that there were several foci of infection which might account for the sporadic occurrence and almost simultaneous discovery of the disease in several other places. Perhaps the disease might have been present in those places for some length of time before it was actually discovered, but since it was localized in certain parts of the field and the damage that it caused was at first rather insignificant, abacá growers failed to notice its presence. In a survey of abacá diseases conducted under the direction of the junior author in places within the limits of Davao City in 1937, the disease was found serious in certain abacá fields in Barakayo, Tongkalan, Gumati, Lipadas, Upper Bayabas, Serib, Manambulan, Catigan, and Cabantian and slight in Mintal. In 1938, the same disease was also found occurring in the Municipal Districts of Saug, Pantukan, Kapalong, and Malita. The prevalence of this disease was not confined within Davao Province. In October, 1938, the junior writer examined the abacá plantations in Kidapawan, Cotabato Province and noted a severe outbreak of similar disease in some of the plantations in that place.

The disease was found principally on Maguindanao abacá at both high and low elevations in Davao City. The claim that

it was present only at high elevations was not quite true. At Lipadas, a place situated near the seashore and about 10 or more feet above sea level, a field of Maguindanao abacá with an area of about half a hectare was totally destroyed by the disease. In the Municipal District of Malita several fields in lower places showed cases of wilt disease. The conspicuous scarcity of this disease at low elevations in Davao City may be attributed principally to the ability of the variety Tañgoñgon (plate 1), which is the main crop in low places, to withstand the attack of the disease. On the other hand, its greater prevalence at high elevations is believed to be due to the more extensive cultivation thereat of Maguindanao, a variety which has been observed to be highly susceptible to the disease. This variety, according to information gathered from various sources, is easily affected by drought; hence, it is not now planted on a large scale in low places where prolonged dry weather occurs occasionally. During the early part of 1931, drought, which continued for about three months, visited Davao City and destroyed about 20,000 hectares of abacá plants.[2] As it was the Maguindanao variety which was most severely affected by that drought, many planters have thought of replacing it with Tañgoñgon and then planting the former at high elevations where the climate is cool and humid. Now, the Maguindanao abacá may be seen growing elsewhere on slopes of mountains where many fields planted to this variety have been found severely affected by the wilt disease.

The bacterial wilt of abacá is usually serious in old neglected plantations [3] where the vital energy of the plants has been greatly impaired by the weedy condition of the field, and where many of these plants have been enfeebled by the attack of weevil-borers such as *Cosmopolites sordidus* Germar and *Odoiporus paganus* Uichanco. Young abacá plantations are also attacked by the wilt disease especially if they are established in wilt-infected places. Recently in January, 1939, the senior writer had occasion to observe a moderate occurrence of wilt disease on the variety Lauan-Tañgoñgon [4] in a field, which, two years ago, had Maguindanao abacá but which was eradicated, due to

[2] Published in the Bulletin of the Japanese Association in Davao, dated May 5, 1931.

[3] During any period when the price of Manila hemp is unusually low, small abacá planters are usually compelled to abandon their plantations because of the high cost of production.

[4] Lauan–Tañgoñgon is a distinct abacá strain or variety which is different from Tañgoñgon, according to Japanese planters in Davao.

the serious prevalence of the wilt disease. The reappearance of the disease in the same field might be due to the faulty disposal of infected abacá debris, despite the rigid recommendations of the Bureau of Plant Industry, and the early replanting of abacá before sufficient time has been allowed to pass to starve out the causal parasite in the soil. The disease is bound to become serious in the same field, if the plants are allowed to remain there for a much longer time.

The wilt disease of abacá spreads rapidly. From foci of infection, it spreads in many directions, but it appears that its spread is much more rapid downhill than uphill. In January, 1939, the infection by the wilt disease in Upper Bayabas and Barakayo was noted along a stretch of about a kilometer below the infected areas which were noted eleven months earlier. Since the disease is soil-borne, it is believed that its rapid spread downhill is due to the movement, during rains, of surface water which carries infected soil and infected abacá débris.

ECONOMIC IMPORTANCE

Among the abacá diseases found in Davao, the wilt disease is undoubtedly the greatest source of loss at present, but no approximate monetary loss can as yet be given. The infection by this disease in individual fields varies from slight to about 75 per cent. A severely affected field is considered a total loss to the planter, as it necessitates a total destruction of the plantation in order to prevent the rapid spread of the disease to neighboring healthy areas. In order to properly evaluate the economic significance of this disease, a systematic survey of the nature and extent of damage that it causes is necessary. In the absence of this type of survey, an idea of the destructiveness of the disease may be obtained from the results of a simple method of abacá-disease survey which the Bureau of Plant Industry instituted some time ago in Davao. The method consisted in locating the infected field and then instructing the owner to eradicate and burn all abacá plants in the diseased field, in order to destroy the source of infection, and prevent the spread of the disease. In this survey the area which was found infected by the wilt disease from May, 1937 to December 1938 totaled 1,301.5 hectares. Since the survey covered only about one-fourth of the total area planted to abacá in Davao it is believed that many more fields of abacá may be found infected by the disease as the survey continues. Of the infected area found in this survey, a total of 1,059 hectares have now been eradicated. The dire situation, now, has been partly

alleviated by planting Tangongon, a variety which has been observed to be resistant to the disease. It is of interest to note in passing that the Tangongon plants, which were recently seen growing in certain fields eradicated lately of the abacá plants affected by the wilt disease in Tongkalan, show prolific tillering and luxuriant growth, and no external signs of wilt infection (plate 2, fig. 2).

DESCRIPTION OF THE DISEASE

The abacá bacterial wilt attacks principally the varieties Maguindanao (plate 2, fig. 1), Lauan-Tangongon, Balindag, and Bongolanon. Slight variations in symptoms of the wilt disease are shown by the different varieties. The writers' study on symptoms of the wilt disease was made more detailed with the Maguindanao variety since it is the one found commonly attacked by the disease in Davao City. This study involves an external inspection of a few thousand plants in different plantations, and the felling or uprooting of about seven hundred plants which were dissected for examination of the internal symptoms and the presence of weevil-borers.

External symptoms.—One of the most important and useful external symptoms by which the disease may be readily diagnosed, and by which it is not likely to be confused with other abacá diseases in Davao, is the production of rusty-brown linear streaks on one or more or all leaves of an affected plant (plates 3 and 4). These rusty-brown linear streaks (plate 5) follow the veins, oftentimes extending throughout the whole length of the veins from the infected midrib to the margin of the lamina. The rusty-brown color spreads laterally from several points along the discolored vein toward the other veins, and blurs the clarity or sharpness of the line (plate 6). When a leaf is severely affected, the streaks appear as many parallel lines originating from the midrib (plates 5 and 6). In some cases, however, the streaks appear as broken, instead of solid lines. Yellowing of the tissues along the veins soon follows the development of the linear streaks. Where the streaks are very near each other, the yellowed areas merge together and may form stripes of yellow coloration (plate 7). In cases where the streaks are more or less uniformly distributed on the lamina, the entire leaf turns conspicuously yellow when viewed from a distance. During cool, wet weather the streaked leaves tend to persist in their normal position for some length of time without showing any sign of wilting. Browning and subsequent drying of the yellowed areas follow, and the leaf thereafter withers. Breaking of the tissues at the petioles or at the

midrib may take place, thereby causing the affected leaf to hang down.

There is no hard and fast rule as to which of the leaves will show first the linear-streaks symptom. In the writers' examination of several affected plants, it was revealed that they may either be the outer or central leaves. There were many cases noted in which only the outer leaves showed the linear-streaks symptom, while the central leaves did not show similar diagnostic features (plate 8). Conversely, there were also several cases in which only the central leaves showed the linear-streaks symptom (plates 3 and 4), while the outer leaves showed normal green color. Whether or not the outer leaves got the infection while they were still heart-leaves has not been ascertained. Future observations will clarify this point.

In the acute case of the disease, the plant rapidly wilts, thereby giving no chance for the formation of the linear-streaks symptom on the leaves. This observation is supported by infection experiments in which wilting and subsequent death of the affected plants took place without showing the linear streaks on the leaves.

A conspicuous retardation in the rate of growth of the rolled central leaf has been observed to be another important symptom of wilt infection. There were cases in which the central leaf ceased to grow before it was totally unfurled. The plants displaying this symptom did not usually show the rusty-brown linear streaks on the leaf blade, but whether the linear streaks were present or absent, the internal symptoms in such plants always bore the characteristic features of the wilt disease. The weakened central leaf was frequently attacked by secondary rots, which usually started at its base and eventually caused its death. Certain observers claim that this type of rotting of the heart-leaf is the result of the attack of weevil-borers in the rhizome or pseudostem. While it is true that similar signs may be produced by the attack of weevil-borers or by the combined attack of these pests and the wilt disease, it is also equally true that in a wilt-infected abacá field a great many of the plants showing such features were seen without even a slight sign of weevil-borer infestation.

Narrowing of the leaves which is commonly observed on the Lauan-Tañgoñgon variety seems to be another feature of the disease. The Maguindanao abacá does not show discernibly this symptom. The narrowed leaf or leaves are frequently observed to be those that follow the streaked-leaf. The three

typical specimens of plants which show narrowing of leaves may be described as follows:

(1) With outer leaf or leaves with linear-streaks symptom, followed by one or two narrowed leaves and then by inner or central normal leaves.

(2) With outer normal leaves, followed by a leaf or leaves with linear-streaks symptom and then by a narrowed inner or central leaf.

(3) Absence of linear-streaks symptom on any of the leaves but with a narrowed inner or central leaf. (Whenever this case was found in the field an internal examination of the plant was always made to determine whether the plant was diseased or not. Every plant which fell under this case always showed typical internal infection by the wilt disease in the pseudostem and corm or corm only.)

The narrowed leaves are generally uniformly green in color, except in rare cases in which such leaves show also the linear-streaks symptom of wilt disease, or in cases in which they become chlorotic due to the mosaic disease to which Lauan-Taŋgoŋgon appears to be very susceptible. Older narrowed leaves have softer petioles and contain less sap than normal ones. Narrowing of the leaves is believed to be due to a disturbance in the growth of the heart-leaves, as a result of wilt infection within the plant. Whether it is a result of a direct or indirect infection of the leaf by the wilt disease, cannot be explained yet. The fact is that narrowing of the leaf blade usually takes place on leaves that follow those which show the characteristic linear streaks on the laminae.

Longitudinal splitting of the pseudostem comparable with that found on bananas affected by the Panama disease caused by *Fusarium oxysporum*(4) has not been observed on abacá plants affected by the wilt disease under study. In some cases, however, splitting of the base of the pseudostem was noted but in no case was it observed to be as prominent or as pronounced as in the Panama disease. Since such splitting may also be observed on healthy plants, it is therefore believed that it may be due to a certain injury which is of mechanical or insect origin rather than to the wilt disease. The split which is short and narrow may be deep enough to injure the bases of one or two layers of leafsheaths.

In lieu of the longitudinal splitting of the pseudostem there may be observed large blackish brown patches of rotting tissues at the base of the pseudostem. Usually this sign is found on plants severely affected by the wilt disease. In humid places the blackish brown patches may be covered by a growth of *Fusarium*, a fungus which has been found in great abundance

even on the old rotting outer sheaths of healthy plants in humid plantations.

In a diseased stool not all of the plants may show the wilt disease. While it is to be expected that older plants show the infection ahead of the younger ones, this does not always happen in many diseased stools examined, as it has been repeatedly observed that younger plants often show definite external symptoms of the disease while the older ones do not display the same symptoms. Since the usual method of infection in a stool is from "parent-to-daughter" plants the uneven distribution of the disease in a stool may be due to the uneven distribution and uneven progress of infection in the daughter plants.

Sword suckers in a diseased stool may die due to a severe infection in the bulb. The dying sword sucker first shows drying and shriveling of its small leaves. This gradually works downward to the base. Rotting follows and eventually causes the final death of the sucker.

Internal symptoms.—The internal symptoms of the wilt disease of abacá may be readily observed by cutting a transverse or longitudinal section of the rhizome and pseudostem. A diseased plant shows discolored vascular strands in the rhizome and pseudostem. Healthy tissues of the rhizome and pseudostem are clean white when freshly cut, but after a few minutes' exposure to air the cut surface turns brown due to oxidizing enzymes in the cells. In an advancing infection the color of the affected vascular strands may vary from orange buff (R)[5] to either Mars yellow (R) or sudan brown (R). In more advanced stages of infection the diseased vascular strands are more deeply stained, raw umber (R), burnt umber (R), or nearly blackish brown (R) being the usual color.

In transverse sections, the infected vascular strands in the pseudostem appear as colored dots (plate 9, fig. 1). In the early stage of the disease or when the infection is light, the discolored vascular strands may be localized in a few sheaths, which may either be the inner or more often the peripheral ones. Likewise, the infection in the rhizome may be localized in certain parts of the stele (plate 9, fig. 2). In serious infections a more or less uniform distribution of infected strands may be observed in both the rhizome and pseudostem. The daughter suckers which may grow out from the diseased por-

[5] Colors indicated in this paper if followed by (R) are those of Ridgway's Color Standards and Color Nomenclature. Washington (1912).

tion of the rhizome may get the wilt infection. The discolored vascular strands may be seen passing out from the diseased stele of the rhizome into the daughter sucker. In a diseased stool some suckers which look apparently healthy may show discolored vascular strands in the rhizome and pseudostem. The infection in those suckers can be traced back to the diseased mother plant. By cutting a series of cross sections from the rhizome to the upper part of an abacá plant seriously attacked by the disease, the infection as shown by the discoloration of the vascular strands can be seen passing out from the stele of the rhizome into the pseudostem, then into the petioles and midrib and then finally into the leaf veins.

A copious exudation of bacterial slime from the severed infected vascular strands comparable with that in bacterial wilt of bananas and plantains(6) caused by *Bacterium solanacearum* E. F. S. has not been observed in the abacá disease under study. However, if the seriously infected tissues were pressed hard, the juice that came out of the cut surface, when examined through the microscope, revealed the presence of actively motile bacteria. The plants which contracted the disease through inoculation did not also show a copious exudation of bacterial slime when the affected pseudostem or rhizome was cut transversely.

In longitudinal sections, the diseased vascular strands appear as colored lines running straight from the corm to the upper portion of the plant (plate 10). By holding the thinner part of a diseased sheath before a transmitted light the discolored vascular strands can also be seen. Rotting of the parenchyma cells at certain points along the infected vascular strands is usually observed. Such rotting may involve several layers of parenchyma cells, and in a serious infection it may involve practically the entire tissues of the affected sheath. The tissues of the rhizome may undergo rotting in almost the same fashion. Patches of rotting tissues may be observed along the discolored strands, and these coalesce to form larger patches which sometimes involve the entire tissues of the stele.

The internal symptoms of the abacá wilt under study are, in many respects, similar to those described for the Panama disease in bananas. Both diseases affect the vascular bundles and cause them to become discolored. The distribution and course of infection and the arrangement of affected vascular strands are almost similar in both diseases. It is difficult to illustrate the difference between the two diseases in the color of the infected strands because this is so variable in abacá disease that

there are cases in which it cannot be sharply distinguished from that in Panama disease. The principal difference in internal infection between these two diseases may be seen in the leaf-crown. In advanced stages of abacá disease the infection can be easily traced by following the discolored vascular strands up to the highest points of the midribs of leaves and out into the laminae in the form of rusty-brown linear streaks. Where a confusing manifestation of the abacá disease occurs due to the absence of linear streaks on the laminae, or because the infection in the pseudostem has not yet reached the leaves, microscopic examination of the infected tissues should be made. Motile bacteria are found in the infected cells of the progressing infection.

ORGANISMS ASSOCIATED WITH THE DISEASE

Bacteria and fungi of the genus *Fusarium* were the organisms found commonly associated with the plants affected by the wilt disease. Weevil-borers such as *Cosmopolites sordidus* and *Odoiporus paganus* may also be found on plants affected by the wilt disease, but perhaps little importance as contributory factors of the abacá wilt can be ascribed to these insects because a majority of the wilt-infected plants examined did not show them. However, their attack weakens the plants and predisposes these to infection, and the injuries that they cause may serve as avenues for the entrance of the parasites into the tissues. Also, the possibility of their being carriers of the disease should not be ignored.

Under the microscope an abundance of actively motile bacteria will always be seen in sections across the rusty-brown linear streaks on the leaves and the discolored vascular strands in the petioles, midribs, and leafsheaths. These linear streaks have already been discussed here as one of the most useful diagnostic symptoms of the disease. Motile bacteria are also found abundantly in the discolored vascular strands in an advancing infection. Cells which are filled with motile bacteria are, however, relatively scarce in deeply stained strands of the pseudostem and corm in advanced stages of infection, the reason for this scarcity being still unknown. Instead of the actively motile bacteria, the mycelium of *Fusarium* may occasionally be found in sections of deeply stained infected strands of the corm and lower portions of the pseudostem. In no case was the mycelium of *Fusarium* found in the affected veins of the leaves. However, the growth of *Fusarium* may be observed in the tissues of the leaves which have undergone an advanced form of rotting.

ISOLATION OF THE CAUSAL PARASITE

The organism that causes the wilt disease of abacá in Davao was isolated with much difficulty. Several attempts were made to isolate it from time to time from the affected tissues in the different parts of the diseased abacá plants, but in nearly all cases a mixture of organisms developed in isolation plates. The type of bacterial colonies that predominated in an isolation might either be scarce or absent in another isolation. Since a mixture of organisms often appeared in isolation plates, a culture of each of the types was, therefore, made and its pathogenicity was immediately tested on abacá plants which were grown from seeds or rootstocks of the susceptible variety. After several isolation and inoculation trials it was found that the pathogenic type of bacterial colony was the one that began to form in three or four days, and bore characters which were similar to those of *Bacterium solanacearum* E. F. S. It was white, wet-shining and showed a tendency to flow. The other types of bacterial colonies which were mostly fast-growing were believed to be those formed by organisms which have followed the infection caused by the primary causal parasite in abacá tissues. Owing to the vigor and more rapid growth of these secondary organisms the primary causal bacteria were often outgrown in isolation plates, hence the latter often could not develop any more. Success in isolating the causal bacteria was obtained from fresh material which showed the progressing infection. They were never isolated from tissues which showed an advanced stage of infection, because a heavy growth of secondary organisms was always obtained from such tissues. The *Fusarium* fungus which occasionally appeared in isolation plates was also cultured, and the rôle that it plays in the wilt-disease complex of abacá in Davao is also being studied.

Isolations were made from the midrib, petiole, sheath, and corm of diseased abacá plants. The material was first dipped in 1:1000 mercuric chloride solution for two minutes, and then washed with three changes of sterile water. With flame-sterilized scalpel the outer layer of tissues was removed and then the discolored inner ones were scraped off little by little. The scrapings were transferred in tubes of either nutrient bouillon or sterile water, and then pressed in the liquid. The cloudiness of the liquid indicated the presence of numerous bacteria. This was proved by microscopic examination of a small drop of the liquid. The bacteria were isolated by means of agar-poured plates.

INOCULATIONS

Materials and methods.—Only abacá plants of the Maguindanao variety were used in the pathogenicity tests. They came from seeds or rootstocks which were obtained from a healthy field in Davao, and were grown in Manila in pots, empty kerosene cans or drums containing garden soil which was previously autoclaved at fifteen pounds' pressure for two hours. The seeds which were obtained fresh from ripe fruits were first soaked in 1:1000 mercuric chloride solution and then sown in pots containing sterilized soil. The young plants which emerged from the seeds after more than twenty days were pricked into the other pots of sterilized soil when they had produced four or five leaves. Before planting the rootstocks they were first thoroughly cleaned of dead and dried tissues, and then they were dipped in 1:1000 mercuric chloride solution for ten minutes after which they were washed with several changes of water. The plants were allowed to grow for some months before they were inoculated.

Inoculations were made by either needle-pricks or hypodermic injections into the midribs of the heart-leaves, the pseudostems, corms, and roots, and by cutting off the sucker buds and smearing the cut surface with bacterial growths. The bacterial cultures used were obtained from two-to three-day-old transfers on potato-dextrose agar. In earlier inoculations the culture used came from an isolate made from freshly collected material. In later inoculations they were obtained from isolations made by passage of the bacteria through the abacá plants. The points to be inoculated were first wiped with clean cotton moistened with sterile water before any pricking or injection was done. Check plants were maintained for every method of inoculation followed.

Pricking the midrib of heart-leaf.—On June 16, 1939 five Maguindanao suckers, varying from 60 to 80 centimeters high [6] were each inoculated by needle-pricks at a certain point on the midrib of an actively growing central leaf. Signs of infection were observed on all of the inoculated leaves after five days. The infection was, however, so slow on two plants that it showed no appreciable progress when the leaves matured. These two plants produced many more leaves but none of them showed the wilt symptoms. In the other three plants the in-

[6] The height of abacá plants indicated here and elsewhere in the paper represents the height from the base of the plant to the point where the heart-leaf emerges from the crown.

fection was so rapid that it caused wilting of the inoculated leaves between the second and third weeks after inoculation. The wilted leaves broke down at the petioles and then rotting followed. The leaves that followed the inoculated ones were slow in growth, and they matured before they were wholly unfurled. These plants ceased to produce more leaves. After one and a half months, they were dug up and examined. The stele of the rhizome and affected sheaths showed discolored vascular strands. The tissues in the upper central portion of the stele showed rotting which had also partly invaded the lower tissues of the centermost sheaths. The causal bacteria were successfully reisolated from affected tissues of the stele and sheath. The needle stabs on the midribs of the heart-leaves of the check plants did not hinder their growth.

On July 7, 1939 the above experiment was repeated on two Maguindanao suckers. Positive results were obtained on one of the plants after a week. Forty-six days after inoculation the infected plant showed the linear-streaks symptoms on the leaf blade of the unfurling heart-leaf, the third that succeeded the inoculated one. On sectioning the plant longitudinally, the internal symptoms in the pseudostem and rhizome showed all the characteristic aspects of the wilt infection.

Pricking the pseudostem.—On June 13, 1939 three Maguindanao suckers, varying from 50 to 120 centimeters high, were smeared copiously near the base of the pseudostem with the bacterial growth from tube cultures on potato-dextrose agar, and then several deep pricks were made through the smear. Between 20 and 30 days after inoculation, the rolled heart-leaf of each of the inoculated plants was observed to be slow in growth and had not unfurled even after two more weeks. When, later, those rolled heart-leaves began to show signs of yellowing, the plants were dug up and examined. Discolored vascular strands, characteristic of the wilt disease, were seen in the inner sheaths and in the stele. Sections across the affected strands showed myriads of actively motile bacteria. The bacteria were successfully reisolated from one of the diseased plants. Check plants showed no symptom of the wilt disease.

On June 16, 1939 the above experiment was repeated on four Maguindanao suckers, but instead of deep pricks only shallow ones were made through the smear. None of the plants contracted the disease.

Pricking the rhizome.—On November 17, 1938 three potted abacá seedlings, ten months old from seed, were inoculated

by needle-pricks into the rhizome. No infection was noted on any of these plants even after four months.

On June 13, 1939 five suckers, varying from 40 to 120 centimeters high, were inoculated by needle punctures into the upper portion of the rhizome. Only two plants showed the infection after about a month. One of the infected plants ceased to produce more leaves because the infection which coursed through its heart-leaf had caused its sudden wilting and subsequent rotting of its tissues. The earliest indication of infection in the second affected plant was discoloration of the inner tissues of the midribs of the two innermost leaves, such discoloration being very distinct when viewed by transmitted light. Linear streaks were beginning to form at certain points on the leaf blade along the midrib of the central leaf, but they showed no further development when the affected leaf suddenly wilted a few days later (plate 11). After two more weeks general wilting of all of the leaves took place, and then the plant died. The affected plants when dissected showed typical internal symptoms of wilt disease in the innermost sheaths and stele. Sections across the diseased vascular strands showed discolored xylem vessels which were teeming with bacteria. The causal bacteria were successfully recovered from the stele, sheath, and midrib.

Injecting bacterial suspension into the midrib of the central leaf.—On October 27, 1938 nine Maguindanao seedlings, five months old were each inoculated by injecting bacterial suspension into the midrib of the unfurled central leaf. The plants were kept in a shady place near the greenhouse. Five of the inoculated seedlings contracted the disease. Between twelve and fifteen days after inoculation a few broken rusty-brown linear streaks (plate 12) began to appear on the leaf blade of the inoculated and succeeding heart-leaves of three of the infected plants. This was later followed by wilting of the streaked leaves. The other two infected plants showed signs of wilting on the inoculated leaves, but they never produced any linear-streaks symptom. General wilting of all of the infected plants (plate 13, fig. 1a) occurred between the sixteenth and twentieth day after inoculation. The diseased plants were dug up and examined. Discolored vascular strands in the midribs of affected leaves, sheaths, and rhizomes were noted. This examination also revealed that the infection which started from the inoculated points in the midrib moved downward into the stele, and from there it spread into the tissues of the succeeding leaf through its sheath. Microscopic sections across the affected vascular strands in the sheath, midrib, and linear streaks on

the leaf blade showed the presence of numerous actively motile bacteria in the xylem vessels and in the parenchyma cells in close proximity to the diseased vascular bundles. The causal bacteria were successfully reisolated from an affected sheath of one of the infected plants. The check plants which were also pricked in the midribs of heart-leaves but into which no bacteria were introduced remained healthy.

On December 3, 1938 six Maguindanao suckers, varying from 40 to 65 centimeters high, were each injected with about 1.0 to 1.5 cc. of the bacterial suspension into the midribs of vigorously growing central leaves. A week after inoculation, infection was noted on three of the inoculated plants. Since the disease affected only a few vascular strands in the midrib, as could readily be seen with the aid of transmitted light, the inoculated leaves did not show any sign of wilting. The infection which moved slowly downward was calculated to have reached the stele between the second and third weeks after inoculation. The two affected plants produced two more healthy leaves, but in each case the third ensuing leaf which appeared seven weeks after inoculation showed the characteristic rusty-brown linear-streaks symptom of wilt disease (plate 14). Sections across the streaks showed numerous bacteria in the vascular bundles. One of these plants soon succumbed. In the other plant the streaked leaf was followed by a narrowed leaf without any streaks. After three more weeks, the streaked leaf wilted. This was then followed by general wilting and later by death of the plant. A large blackish brown patch of rotting tissues (plate 15, fig. 2) was also produced at the base of this plant. The third affected plant produced two more leaves, but its last leaf ceased growing while it was partly unrolled. All of the diseased plants on dissection showed discolored vascular strands (plate 15, fig. 3) which were teeming with bacteria. The check plants which were injected with sterile water at the midribs of the central leaves showed absolutely no sign of wilt disease.

On December 6, 1938 the same method of inoculation was followed for six potted Maguindanao seedlings, 10 months old. Incipient infection was noted on two plants, but no further progress of the disease was observed even after 3 months.

Injecting bacterial suspension into the pseudostem.—Thirty-six Maguindanao seedlings, 10 months old were inoculated by injecting bacterial suspension into the pseudostem on December 6, 1938. Of this number only ten plants contracted the dis-

ease. Seven of the infected plants, some of which appear in plate 13, fig. 2, showed signs of wilting during the fourth week after inoculation. Only one plant showed the typical linear-streaks symptom before it finally succumbed. The rest of the infected plants later showed rotting of the heart-leaf. All of the infected plants, on dissection, showed the typical internal symptoms of the wilt disease in the stele and in the affected sheaths (plate 15, fig. 1a) and midribs. The wilt disease was not observed on any of the ten check plants used.

Injecting bacterial suspension into the corm.—No successful result was obtained with this method of inoculation. The tissues of the corm, being compact, would not hold the bacterial suspension. When pressure was applied to the plunger of the syringe, the liquid was forced out, hence probably not much bacteria were left in the injured tissues.

Cutting off the sucker bud and smearing the cut surface with bacterial growth.—On November 17, 1938 one of the three actively growing sucker buds of a potted Maguindanao plant, 9 months old, was cut off close to the mother plant, and then the cut surface was smeared with the bacterial growth from a 3-day old culture on potato-dextrose agar. The two innermost leaves of the mother plant wilted two weeks after inoculation. General wilting followed later and then the plant died. A month later the two other suckers, which at this time had each formed two leaves, began to show signs of rotting at the base of the youngest leaf. Rotting on these two suckers continued until they all died.

General remarks on results of inoculations.—It will be seen in the results of the above infection experiment that the inoculated abacá plants showed an irregular response to the wilt organism. Many inoculated plants did not show any sign of infection at all; others contracted the disease with rapidity; others have shown some signs of infection but ceased to show any further progress; still others showed the disease after a considerable length of time. The external manifestations of the wilt infection, as a consequence of inoculation, have also shown some variations. In some plants these were shown by wilting of either the innermost leaves or the entire foliage; in others, by the retarded or arrested growth and rotting of the heart-leaf; and still in others, by the production of linear streaks on the leaf blade. These differences in the response of the abacá plants to inoculation with wilt organism are not clearly understood. They seem to depend partly on the indi

vidual differences in susceptibility or resistance of the plants, partly on the succulence and tenderness of tissues, partly on the environmental factors existing during the inoculation experiment, partly on the virulence of the culture, and partly on the method and technic of inoculation.

The Maguindanao suckers used in the inoculation experiments, which were grown from rootstocks, were obtained from the different clones in a field of Maguindanao abacá in Davao. Since they did not come from a single clone they, therefore, might vary in degree of their natural susceptibility or resistance to the disease. The plants grown from seeds are supposed to be natural hybrids because the abacá flowers, according to Mr. T. G. Garrido, plant breeder of the Bureau of Plant Industry, are never self-pollinated. The pollen necessary for the fertilization of the flowers of an individual plant must always come from some foreign source, and it is very likely that the source is not only one plant but many plants, in which case the fertilized seeds in a single bunch might have not only one male parent but many male parents. This difference in parental origin might account for the difference in the degree of susceptibility or resistance to the wilt disease of the plants grown from such seeds.

It has been repeatedly observed that when inoculation was made into the mature tissues no infection resulted. A mature heart-leaf which was inoculated by needle-puncture or by injection into the midrib never produced an infection. An infection was frequently obtained when this method of inoculation was applied to the actively growing rolled heart-leaf. If the same method of inoculation is applied to the pseudostem, the point of the needle must reach the tender inner tissues in order to produce an infection. Shallow needle-pricks injured only the mature tissues of the outer leaf sheaths; hence, no infection resulted.

A greater percentage of success in inoculation was obtained during humid days. The most typical linear-streaks symptom that resulted from inoculation was produced in one that was made in the early part of the cool, showery December of 1938. This symptom was shown by the inoculated plants during the latter part of January, 1939. More rapid wilting of plants that contracted the disease by inoculation took place during hot days.

With a virulent culture, an inoculation by needle-punctures or by injection into an abacá plant could cause an infection within

a period of usually not more than two weeks. Any of the external features of the disease, such as wilting, retarded growth of the heart-leaf, and formation of linear streaks might manifest within one and a half months.

SUMMARY

1. An investigation on a serious wilt disease of abacá which has been found widespread in Davao Province and in a few places in Cotabato Province is now being undertaken. This disease caused much alarm in Davao City during the year 1937 because of the heavy destruction that it wrought on abacá in that place.

2. In an abacá-disease survey which was conducted by the Bureau of Plant Industry from May, 1937 to December, 1938, a total of 1,301.5 hectares of abacá plants in Davao was found infected by the wilt disease. Of this infected area, a total of 1,059 hectares has already been eradicated. These figures have sufficiently shown that the disease is one of major economic importance.

3. One of the most important diagnostic external symptoms of the disease is the production of rusty-brown linear streaks which follow the veins of the leaves from the infected midrib. The formation of linear streaks is followed by yellowing and subsequent wilting of the affected leaf, and death of the tissues in the yellowed areas. In acute cases of the disease, the plants rapidly wilt without showing any linear-streaks symptom. The other external features of the wilt disease which may aid in its diagnosis are retarded or arrested growth of the heart-leaf, and in certain cases, narrowing of the leaf or leaves which usually follow the streaked ones. Narrowing of the leaves is commonly observed in wilt-infected plants of the Lauan-Tangongon variety. General wilting of the leaves is usually observed in serious and advanced stages of the disease. Large blackish-brown patches of rotting tissues may also be observed at the bases of the pseudostems of some affected plants.

4. An internal examination of the rhizome and pseudostem of an affected plant shows that the infection follows the vascular strands. The infection in a plant seriously affected by the disease can be traced by following the discolored vascular strands from the rhizome, through the pseudostem up to the petioles and midribs and out into the leaf veins. The internal infection shows many features similar to those described for the Panama disease of bananas.

5. Weevil-borers such as *Cosmopolites sordidus* and *Odoiporus paganus* may be found in abacá plants affected by the wilt disease, but perhaps they are not very important as causal factors of the disease because a majority of the plants examined did not show them. However, the weakening effects of their attack cause the plants to become very susceptible to wilt infection.

6. Microscopic examinations of the diseased tissues have shown an abundance of actively motile bacteria in sections across the rusty-brown linear streaks on the leaves, and also in the affected vascular strands of the rhizome, pseudostem, petiole, and midrib in the early stages of the disease. They are, however, not very abundant in deeply stained vascular strands of the rhizome and pseudostem in advanced stages of the disease, the reason for this being still unknown. The mycelium of the fungus *Fusarium* may also be found associated with the deeply stained strands of the rhizome and pseudostem but in no case has it been found in the infected veins of the leaves.

7. The causal bacterium was isolated with much difficulty because its colonies were slow-growing and oftentimes would not develop in isolation plates in the presence of other fast-growing secondary bacteria, which were believed to have invaded the abaca tissues following the primary infection. The appearance and character of the colonies were similar to those described for *Bacterium solanacearum*, the bacterium that causes a wilt disease of certain varieties of bananas and also of the solanaceous plants.

8. Inoculations of several Maguindanao abacá plants grown from seeds or rootstocks by either pricking or hypodermic injection into the midrib of an actively growing heart-leaf, pseudostem and corm have yielded some successful results. One or more of the typical external symptoms of the disease were reproduced in all of the methods of inoculation followed except in hypodermic injection into the corm. The internal infection in all plants that contracted the disease through artificial inoculation has also shown close similarity to that found in nature. Microscopic sections across the infected vascular strands and veins of the leaf showed numerous actively motile bacteria in the xylem vessels and also in the parenchyma cells in close proximity to the affected bundle. Successful reisolations were made from some of the inoculated plants that contracted the disease.

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LITERATURE CITED

1. Calinisan, Melanio R. Vascular disease of abacá (Manila hemp) in Davao: Progress Report No. 1. Phil. Jour. Agr. 9 (1938) 153–160. Pl. 1–11.
2. Ocfemia, G. O. The abacá-disease situation in Davao. The Philippine Agriculturist 26 (1937) 229–239. Figs. 1–2.
3. ..... A banana disease destructive to abacá at high elevation in Davao. Agricultural and Industrial Monthly 4 (1937) No. 10, 8–9. Figs. 1–3.
4. ..... Davao abacá disease. The Monday Mail Business Week. June 21, 1937. p. 2.
5. ..... The abacá wilt in Davao. Philippine College of Agriculture Bi-weekly Bulletin 6 (1938) No. 19, 1–2.
6. Wardlaw, C. W. Diseases of the banana and of the Manila hemp plant. 1935. xii + 615 pp. London: Macmillan & Co., Limited.

ILLUSTRATIONS

Plate 1

A stool of Tañgoñgon from the only plant of this variety which was accidentally planted together with Maguindanao abacá some years ago in a 6-hectare field in Gumate, Davao City. The Maguindanao abacá had been eradicated due to the serious infection of the wilt disease. The Tañgoñgon was spared because it did not show the disease. The small abacá plants that are seen in the picture are also of the Tañgoñgon variety, planted a few months after the destruction of the wilt-infected Maguindanao plants.

Plate 2

Fig. 1. A portion of a wilt-infected plantation of Maguindanao abacá in Gumate, Davao City, showing some plants killed by the disease.

2. A stand of Tañgoñgon abacá, about 18 months old in a 3-hectare field in Tongkalan, Davao City in which a serious incidence of the wilt disease on Maguindanao abacá was observed by the junior writer in the latter part of 1936. After the eradication of wilt-infected Maguindanao abacá, two successive crops of corn were grown in the same field and then during the latter part of 1937, the Tañgoñgon abacá was planted. The Tañgoñgon plants now show luxuriant growth and prolific tillering and an absence of external signs of wilt infection. Photographed March 22, 1939.

Plate 3

A sucker of Maguindanao abacá showing distinctly the linear-streaks symptoms of wilt disease at the basal part of the lamina of the unfurling central leaf. The specimen was collected in March, 1938 in Barakayo, Davao City. About X $\frac{1}{2}$.

Plate 4

A wilt-infected sucker of the Maguindanao variety showing the rusty-brown linear streaks on the rolled heart-leaf. The heart-leaf was unrolled to show clearly the linear streaks and the rotting tissues at the basal part. The specimen was collected in April, 1938 in Gumate, Davao City. About X $\frac{1}{3}$.

Plate 5

A portion of a leaf of an almost full-grown Maguindanao abacá showing the linear-streaks symptom of wilt disease. Note yellowing of tissues along and between the streaks. The specimen was collected in April, 1938 in Barakayo, Davao City. About X 1.

Plate 6

A portion of a wilt-infected leaf showing clearly the linear streaks and the spread of infection to neighboring tissues along the streaks. Note that in certain parts of the specimen the streaks appear as many parallel lines running toward the margin of the leaf from the midrib. The specimen was collected in March, 1938 at Upper Bayabas. Slightly more than X 1.

PLATE 7

Wilt disease on Maguindanao abacá. Note the yellow stripes on the unfurled part of the central leaf. The yellow stripes indicate the parts where the linear streaks may be seen. Shriveling of the tissues at the base of the third leaf may also be seen in the picture. About X ⅓.

PLATE 8

A sucker of Maguindanao abacá showing the linear-streaks symptom of wilt disease on the second leaf. The central leaf does not show similar symptom. The specimen was collected in March, 1938 in Lipadas (about 10 or more feet above sea level), Davao City.

PLATE 9

FIG. 1. A transverse section of a pseudostem of Maguindanao abacá seriously attacked by the wilt disease. Note the distribution of infected vascular strands and the blackening of some of the peripheral sheaths due to secondary rots.

FIG. 2. A transverse section of the rhizome of a wilt-infected Maguindanao abacá showing distinctly the disease in a sector. (Specimens used in this plate were obtained on March 27, 1939 in Tongkalan, Davao City, from plants which showed the linear-streaks symptom of wilt disease on the leaves and an absence of the attack of both root-weevil and stem-weevil).

PLATE 10

Longitudinal sections of a Maguindanao abacá stalk collected in Tongkalan, Davao City showing the wilt-disease in the rhizome and pseudostem. The leaves of this plant showed the linear-streaks symptom of the disease and an absence of weevil-borers in the pseudostem and rhizome. Photographed March 22, 1939.

PLATE 11

Abacá plants of the Maguindanao variety inoculated by needle punctures into the rhizome. Two of the plants (pointed by arrows) contracted the disease. Note that on one of the infected plants the two wilted innermost leaves have broken down at the petioles due to loss of turgidity. The other plants did not get the infection. About X ⅒.

PLATE 12

A portion of a leaf of a Maguindanao seedling, which was inoculated by hypodermic injection into the midrib of an actively growing heart-leaf, showing the linear-streaks symptom of the wilt disease on the lower portion of the leaf blade. Note that the linear streaks appear as broken lines instead of continuous lines running from the midrib to the margin of the leaf. Such formation of linear streaks was also observed in nature. Slightly more than X 1.

PLATE 13

FIG. 1. Potted Maguindanao seedlings. About X ⅛.

a. Four of the nine Maguindanao seedlings which were inoculated with wilt bacteria by hypodermic injection into

the midrib of an actively growing heart-leaf. Note the two wilted plants in the foreground. The other two plants in the same pot did not show the wilt symptoms.

b. Check plants.

FIG. 2. Potted Maguindanao seedlings inoculated with wilt bacteria by hypodermic injection into the upper portion of the pseudostem. Two of the plants showed signs of wilting and shriveling of the leaves as a result of infection by the wilt bacteria. About X ⅓.

PLATE 14

Section of a leaf of one of the abacá suckers inoculated by hypodermic injection with wilt bacteria, showing the typical rusty-brown linear-streaks symptoms of wilt disease on the leaf blade. Only a portion of the leaf is shown as the drawing of the entire leaf was too large for this plate. The leaf remained attached to the plant while it was being drawn. Drawing was started on February 7 and finished on February 14, 1939. All of the details shown in the drawing were those exhibited by the leaf on the day it was finished. Slightly less than X 1.

PLATE 15

FIG. 1. Longitudinal sections of abacá seedlings of the Maguindanao variety. Almost X 1.

a. Sections of seedlings inoculated by hypodermic injection into the upper portion of the pseudostem. Note the infection on the pseudostem and stele of the rhizome.

b. Section of one of the check plants. The tissues in this section were white immediately after cutting, but after a few minutes' exposure they began to show some browning due to the presence of oxidizing enzymes in the cells.

FIG. 2. An inoculated Maguindanao abacá showing a black patch of rotting tissues at the base of the pseudostem. This plant was inoculated on December 3, 1938 by injecting a water suspension of wilt bacteria into the midrib of the rolled heart-leaf. Typical linear-streaks symptom of wilt disease on the central leaf was produced after seven weeks. Slightly more than X 1.

FIG. 3. The same plant shown in fig. 2, cut longitudinally to show the internal infection. Note the discolored vascular strands and rotting tissues along them. About X 1.

PLATE 1.

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PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

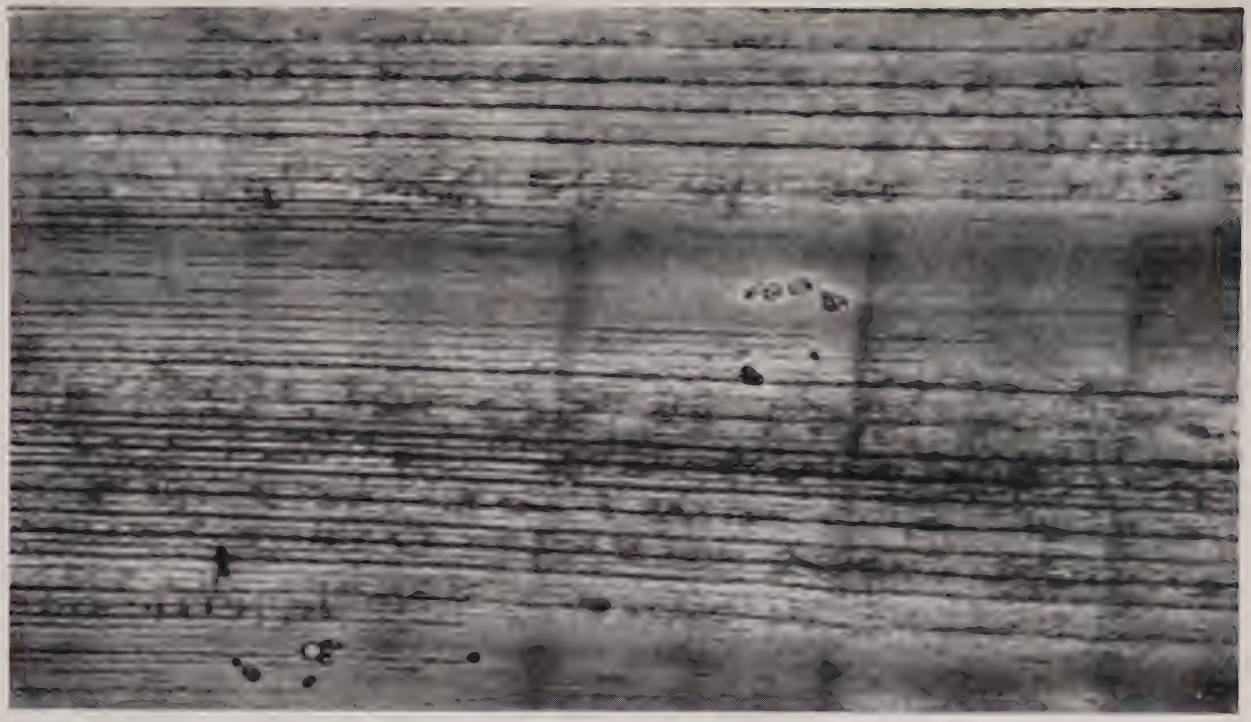

PLATE 6

PLATE 7.

PLATE 8.

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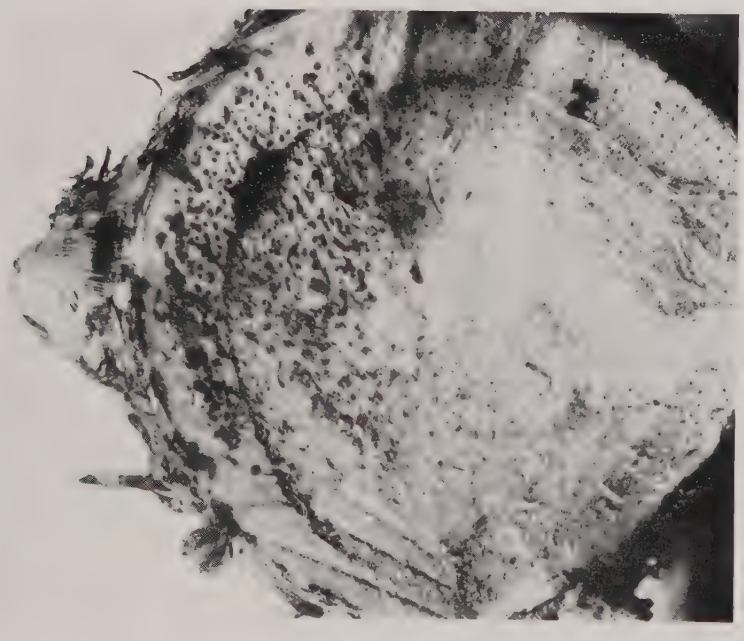

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PLATE 9.

PLATE 10.

PLATE 11.

PLATE 12.

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PLATE 13.

PLATE 14.

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PLATE 15.

NOTES ON THE PRELIMINARY CULTURAL TRIAL WITH CHINESE WATER CHESTNUTS (*ELEOCHARIS TUBEROSA* SCHULTES)

By Nicanor G. Teodoro and Filemon Q. Abaya

Of the Los Baños Economic Garden
Bureau of Plant Industry

EIGHT PLATES

The Chinese water chestnut (*Eleocharis tuberosa* Schultes) is a perennial sedge which is widely cultivated in China, under the names "ma-ti", "o-yu", and "po-tsai".[1] This plant is known in the Philippines as "apulid sungsung." The tubers are dark-colored and small, measuring from 2 to 3 centimeters in diameter. They are boiled and eaten as a vegetable. The plant is closely related, as the generic name indicates, to the native apulid (*Eleocharis dulcis* Burn. f. Trin.) which is found growing in swamps and flooded rice fields in the Philippines. The native apulid, however, is smaller than the "apulid sungsung." The present paper is a report covering the results of the authors' preliminary study on the culture of "apulid sungsung."

Last year, the Economic Garden received two lots of Chinese water chestnut tubers. One lot, consisting of only eight tubers, was brought in on March 21, 1938 by Mr. Filemon Q. Abaya who obtained the tubers from a relative who had returned home from Hongkong, China; and another lot, of sixty-three tubers, was received on July 6, 1938, from the Central Office of the Bureau of Plant Industry in Manila, which imported same from China.

These two lots furnished the materials for our cultural studies on this particular plant.

For convenience the first lot is designated as Lot 1 and the second, as Lot 2.

Lot 1.—On March 23, 1938, all the eight tubers were planted in a seed box containing ordinary garden soil. On March 29, 1938 only six tubers germinated. On May 4, 1938 the young

[1] A Dictionary of the Economic Products of the Malay Peninsula 1 (1935) p. 907.

plants were transferred into the earthern pots containing o dinary garden soil. On May 17, 1938 all the pots were plac in a previously prepared rice paddy near the nursery sh where they were kept submerged in water. After a week t plants were noticed to be producing young suckers, and so, June 1, 1938, all the six plants were removed from the po and transplanted into the mud of the same rice paddy. At t time of transplanting the height of the mother plants was abo 80 centimeters, while the suckers were about 20 centimete On July 1, 1938, 52 young suckers were separated from t mother plants and pricked into another portion of the padd The distance of planting was 50 centimeters between plan The entire planting of the material of this lot covered an ar of 20 square meters (plate 1, fig. 1).

The plants flowered on August 7, 1938, and about two wee from flowering, the tubers became ready for harvesting.

On October 25, 1938, when the plants, numbering 563, we about 80–100 centimeters high (plate 1, fig. 2) the tubers we harvested, yielding a total number of 1,142 tubers (plate fig. 1) weighing 15 kilos, or an average of 76 tubers per kilo.

Lot 2.—On July 7, 1938, all the tubers were planted follows: 25 tubers were sown in a seed box containing ordina garden soil, while 38 tubers were sown on a raised bed (10 c high) prepared in a corner of another rice paddy near t cage of the giant toad in the Systematic Garden, Field A. Th paddy is partly shaded by acacia trees growing nearby; ho ever, owing to lack of available land this paddy was used. July 12, 1938, twenty tubers germinated out of the twent five tubers planted in a seed box, and only twenty germinat out of the thirty-eight tubers planted in the raised bed. both cases, those tubers which failed to germinate were fou decaying. On August 5, 1938, all the young plants were tra planted into the mud of the same paddy. The plants we planted 50 centimeters apart.

On January 13, 1939, a total of 437 tubers, weighing kilos, was harvested when the plants were about 80 centimete high.

During the progress of this preliminary study, the autho attention was directed to the gross study of the methods reproduction of this exotic plant, with the end in view determining how best it can be propagated and how rapi it can be multiplied under Los Baños conditions. During ha vesting great care was exercised in digging out the plants a

removing the tubers from the mud, so as to prevent the stolons from breaking apart and so as to keep the tubers intact. In this way, it became possible to determine the number of culms or plants which were connected together by horizontal stolons anastomosing in the soil. It was found that several culms numbering from three (plate 6) to seven or more (plate 7), were connected by stolons.

Two kinds of stolons were observed, namely, a stolon-producing tuber (plate 3; plate 4, fig. 1; and plate 5, fig. 1), and a stolon-producing plant or culm (plate 3 and plate 6, fig. 2).

The stolon-producing tuber is characterized by the swelling of its free end which is markedly noticeable even at the beginning of the emergence of a young stolon from the base of the culm as may be seen in plate 3, fig. 1. And as the stolon elongates this protuberance becomes bigger and bigger as shown in plate 3, fig. 2, plate 4, fig. 1, and plate 5, fig. 1, until finally it assumes the size and shape of a tuber as shown in the various plates and figures. A mature tuber (plate 3, fig. 2, indicated by middle arrow; and plate 6, fig. 2, tuber at left) remaining in the soil germinates and produces a culm. While the stolon-producing tubers are normally produced from the bases of the culm, still there are some stolon-producing tubers which spring from the body of a horizontal stolon as indicated by an arrow in plate 4, fig. 2.

The stolon-producing culm or plant is characterized by a sharp free end, without any protuberance, in contrast with the stolon-producing tuber. This characteristic is distinctly shown even at the incipient growth of this kind of stolon as indicated by the left and lower arrow in plate 3, fig. 1, and by the left and upper arrow in plate 3, fig. 2. The stolon-producing culms or plants are well illustrated in plate 4, fig. 1 by a small culm developing at the extreme right of the figure, and in plate 5, fig. 2, by the several secondary plants developing from the mother culms or plants.

Under the methods of propagation described above, two or three crops were harvested from the original planting. The first crop (plate 8, fig. 1–A & B) produced the largest number of tubers (plate 1, fig. 3), while each of the second and third crops (plate 8, figs. 2 and 3) produced shorter culms and smaller quantities of tubers, respectively.

After removing the tubers from the clumps, there were found secondary stoloniferous growths, and believing that these

clumps bearing such growths could be utilized for furth propagation, the tops of the stalks or culms were cut off, leavi about a foot of same with the clumps as shown in plate 2, f 2, and the same was set aside for the purpose above mention

Using the materials obtained from this preliminary trial more extensive study on the culture of "apulid sungsung", su as the determination of the comparative yield of the tube versus the clumps, and the planting of cured tubers at vario intervals, etc., are underway. The results of this study w be embodied in the next more or less comprehensive report the present authors.

ILLUSTRATIONS

Plate 1

Fig. 1. A paddy of Chinese water chestnut (*Eleocharis tuberosa* Schultes).
2. Several clumps of Chinese water chestnut, showing tubers.
3. A close-up view of fig. 2.

Plate 2

Fig. 1. Newly harvested tubers of Chinese water chestnut ready for the market, or for curing for future planting.
2. Clumps of Chinese water chestnut to be used for planting. Note that the tubers and tops had been removed.

Plate 3

Fig. 1. A close-up view of four clumps of Chinese water chestnut ready for planting. Note the germinating stolons, or rhizomes.
2. Two clumps of Chinese water chestnut connected by a stolon. Note the mature tubers and two young stolons—a stolon-producing clump, characterized by a pointed free end (pointed by an arrow at top left corner), and a stolon-producing tuber, characterized by a swollen free end (pointed by an arrow at lower left side of the figure).

Plate 4

Fig. 1. A clump of Chinese water chestnut, showing a young stolon-producing tuber (at left), and a stolon-producing clump or plant (at right). Note the four mature stolon-producing tubers.
2. Two clumps of Chinese water chestnut connected by a stolon. Note the two stolon-producing tubers arising from the body of the stolon at the point indicated by an arrow.

Plate 5

Fig. 1. A clump or stool of Chinese water chestnut showing young stolon-producing tubers.
2. Three clumps or stools of Chinese water chestnut, showing young plants arising from the bases of the parent clumps or plants.

Plate 6

Fig. 1. A mature Chinese water chestnut plant, showing stolon-producing tubers and a stolon-producing clump or plant at right of the figure.
2. A mature Chinese water chestnut plant, showing stolon-producing tubers. Note at left side of the figure a long stolon bearing a tuber which in turn is producing a new plant or clump.
3. Three clumps or plants of Chinese water chestnut connected together by stolons.

PLATE 7

FIG. 1. Three clumps or plants of Chinese water chestnut with their connecting stolons.

2. Several clumps or plants of Chinese water chestnut showing their connecting stolons. Note how one clump or stool or mother plant can produce several clumps or stools. (From three to seven or more stolon-producing clumps or stools or plants, and several stolon-producing tubers).

PLATE 8

FIG. 1. (A) A bunch of mature Chinese water chestnut plants representing the mother plants or those produced by the originally planted tubers. Note the height of the culms and the heavy production of tubers. (B) Close-up view of (A).

2. (A) A bunch of mature Chinese water chestnut plants representing the first offspring of the mother plants. (B) Close-up view of (A).

3. A bunch of mature Chinese water chestnut plants representing the second or third generation of plants. (B) Close-up view of (A).

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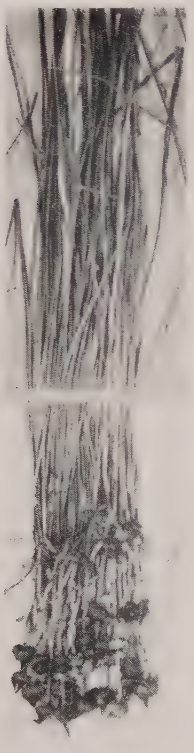

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PLATE 1.

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PLATE 2.

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PLATE 3.

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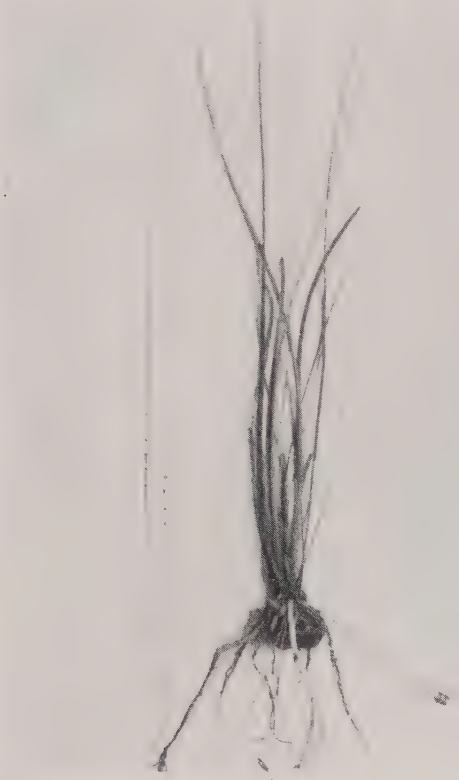
PLATE 4.



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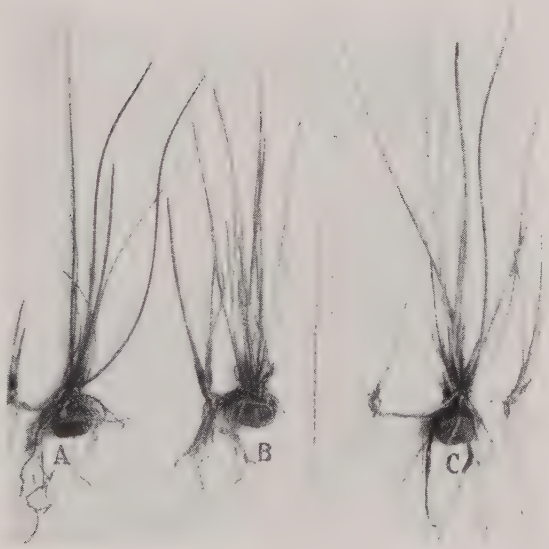

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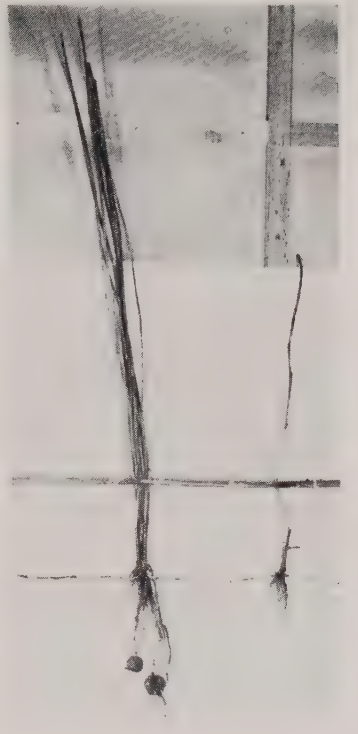
PLATE 5.



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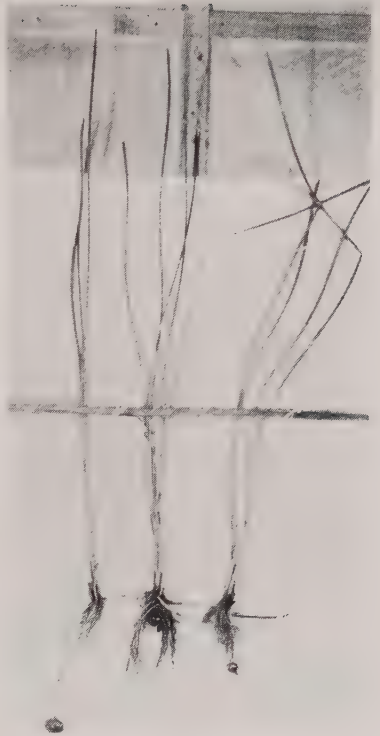

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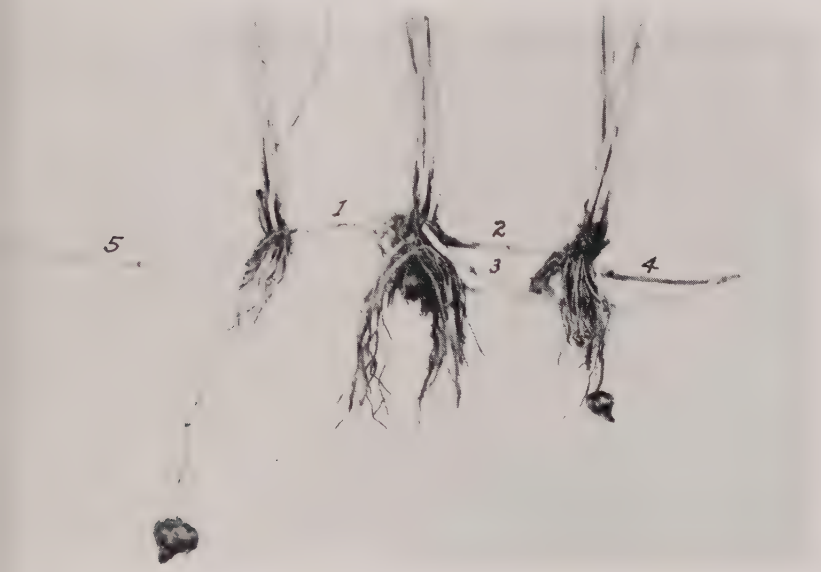
PLATE 6.



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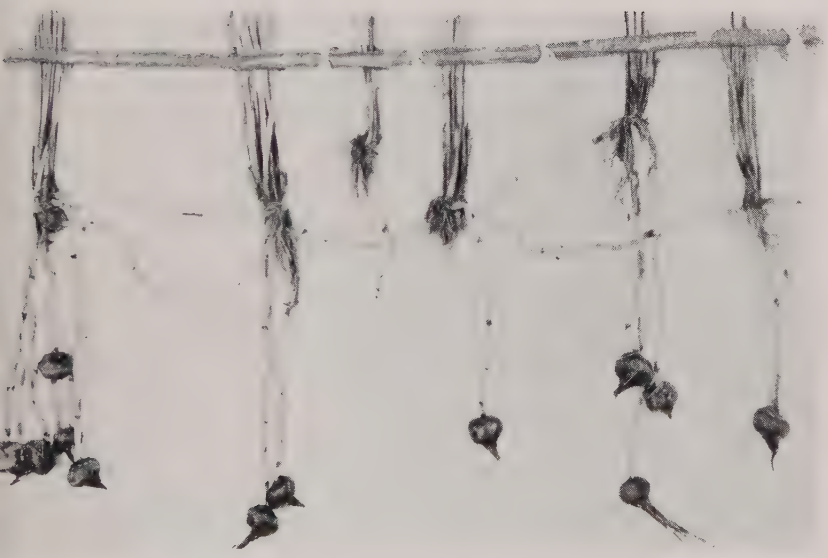

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PLATE 7.

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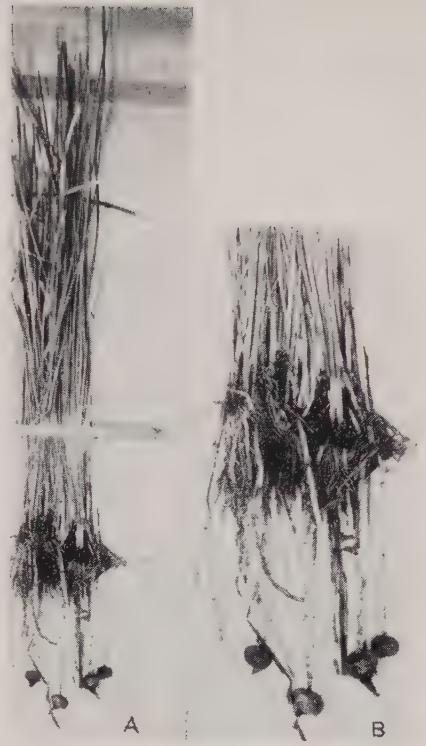

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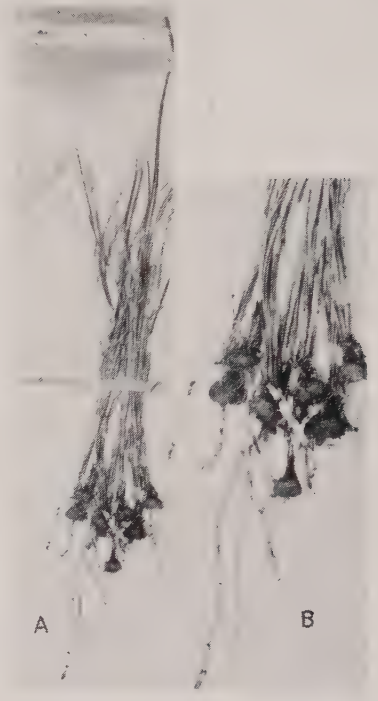

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PLATE 8.

FURTHER ACCLIMATIZATION STUDIES ON CAULIFLOWER

By P. A. Rodrigo
Of the Horticulture Section, Bureau of Plant Industry

TWO PLATES

The first successful attempt in the Philippines to grow cauliflower at sea level was first reported in 1934.[1] In this report, Early Patna was the only variety that produced curd (head) successfully out of a number of varieties tried. The curd of this variety, however, as grown locally is comparatively small and not so compact and solid as that imported from the United States and Australia. Nevertheless, this was considered a distinct contribution to the development of the local vegetable industry, and as a result, the culture of cauliflower has been gaining in popularity in different parts of the Islands.

It is in the interest of this growing industry, coupled with the desire to see cauliflower become a common article of food and not only a delicacy, that the present work was undertaken, which had as its main objective the search for some varieties of cauliflower that are superior to the Early Patna variety.

This study was conducted at the Central Experiment Station of the Bureau of Plant Industry, Malate, Manila. The first set of culture was started in September, 1934, and the last test was harvested in February and March, 1939.

MATERIALS AND METHODS

In this study, 19 varieties of cauliflower were used, including Early Patna, which was used as the standard. These varieties were imported from the United States, Great Britain, India, and the Federated Malay States. The different varieties were not all cultured at the same time; some varieties were tested only once for obvious reasons, while others were cultured two or more times. Where a variety was tested more than once, seeds of this variety were imported every season from the same seed house. Eight separate cultures were made during a period of five vegetable seasons. The varieties tested and their countries of origin are listed in table 1.

[1] Rodrigo, P. A., P. S. Urbanes, and P. Hernaiz. A progress report on the acclimatization of cauliflowers, 1933–1934. Phil. Jour. Agr. 6 (1934) 115–127.

TABLE 1.—*Showing the varieties tested and the countries of origin.*

Variety Name	Origin
Burpeana	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Burpee's Fordhook	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Burpee's Ideal Snowball	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Chinese	Obtained locally but originally from China
Dry Weather	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Early Benares	Sutton & Sons, Ltd., Calcutta, India
Early Italian Giant	Steckler Seed Co., Inc., New Orleans, U. S. A.
Early Market	Sutton & Sons, Ltd., Calcutta, India
Early Patna	Sutton & Sons, Ltd., Calcutta, India
Early Snowball	Steckler Seed Co., Inc., New Orleans, U. S. A.
Henderson's Primosnow	Peter Henderson & Co., New York, N. Y., U. S. A.
Henderson's Snowball	Peter Henderson & Co., New York, N. Y., U. S. A.
Large Algiers	Steckler Seed Co., Inc., New Orleans, U. S. A.
Maincrop Benares	Sutton & Sons, Ltd., Calcutta, India
Maincrop Patna	Sutton & Sons, Ltd., Calcutta, India
Merveille de Tout Saison	Kuala Lumpur, Federated Malay States
Sutton's All the Year Round	Sutton & Sons, Ltd., Reading, England
Sutton's Improved Snowball	Sutton & Sons, Ltd., Reading, England
Sutton's White Queen	Sutton & Sons, Ltd., Reading, England

In all the cultures, the seedlings were set in two-row beds, 50 centimeters between the rows and 60 centimeters between the plants. All the plots were fertilized with nitrophoska (16.5–16.5–20) at the rate of 300 kilograms per hectare. The fertilizer was applied just before planting and thoroughly mixed with the soil in the holes made for the reception of the seedlings.

All the cultures were regularly weeded and cultivated. When the seedlings were well started in their growth, they were twice dressed with ammonium sulphate at the rate of 80 kilograms per hectare. The cultures were watered in such a way as to keep the soil moist all the time. The irrigation was done by

letting the water flow between the rows of cauliflower. To control repressive agencies, particularly cabbage worms, the plants were regularly sprayed with soap and Imazu insect powder. As much as possible, the different varieties were treated in practically the same way, especially those that were cultured at the same time.

Several cultures were undertaken from 1934 to 1939—three cultures during the 1934–1935 vegetable season, one during the 1935–1936 season, two during the 1936–1937 season, one during the 1937–1938 season, and another one during the 1938–1939 season.

EXPERIMENTS AND RESULTS

Cultures of the 1934–1935 vegetable season.—As already stated, three sets of plantings were made, one in the month of September, another in October, and the last in December. The stand of the three cultures was good. Besides Early Patna, two new varieties produced heads. The results of these tests are summarized in table 2.

TABLE 2.—*Results of the cauliflower acclimatization test in 1934–1935*

Variety name	Area of plot	Per cent heading	Actual yield	Average weight per head	Computed yield per hectare	Relative yield
	Sq. m.		*Kg.*	*Gm.*	*Kg.*	*Per cent*
1st planting—Sept. 24, 1934						
Early Patna	12	76.8	4.396	102	3,663.2	100
Early Benares	24	75.9	7.323	86	3,050.8	83
Maincrop Patna	24	33.0	3.427	92	1,427.7	39
Maincrop Benares	12	0				
2nd planting—Oct. 23, 1934						
Early Patna	31	89.8	17.287	150	5,575.0	100
Early Benares	31	56.3	8.301	113	2,676.9	48
Maincrop Patna	24	46.0	5.193	117	2,162.8	39
Maincrop Benares	24	0				
Chinese	24	0				
3rd planting—Dec 8, 1934						
Early Patna	30	73.8	9.898	106	3,299.1	100
Early Benares	20	60.7	6.189	121	3,094.3	94
Maincrop Patna	20	15.5	0.974	75	486.8	15
Maincrop Benares	20	0				
Henderson's Primosnow	20	0				
Henderson's Snowball	20	0				
Sutton's All the Year Round	20	0				
Sutton's Improved Snowball	20	0				
Sutton's White Queen	20	0				
Chinese	20	0				

1935–1936 culture.—Four varieties were the subject of this study. All of them were able to produce curds. The results obtained are summarized in table 3.

TABLE 3.—*Results of cauliflower acclimatization test in 1935–1936*

Row number[1]	Variety			
	Merveille de Tout Saison	Early Patna	Early Benares	Early Market
	Kg.	*Kg.*	*Kg.*	*Kg.*
1	0.27	0.95	0.68	1.48
2	0.48	0.87	0.31	1.27
3	0.27	0.85	0.75	2.02
4	0.47	1.10	0.83	1.69
Mean	0.37±0.03	0.94±0.03	0.64±0.04	1.61±0.09
Standard deviation	0.10±0.02	0.098±0.02	0.12±0.03	0.28±0.06
Coefficient of variability	27.02±6.84	10.42±2.49	18.75±4.53	17.39±4.18
Computed yield per hectare	587.3	1,492.1	1,015.9	2,555.6
Relative yield	39.1	100	68.1	171.3
Per cent heading	66.2	96.2	88.5	96.3

[1] Length of row was 12.6 meters, equivalent to 6.3 sq. m. The plots were prepared as raised beds.

1936–1937 culture.—Two sets of planting were made. In one of the cultures, three varieties were tested and in the other only two were cultured. Tables 4 and 5 present the summarized results of these tests.

TABLE 4.—*Results of the 1936–1937 cauliflower test*

Row number[1]	Early Patna	Early Benares	Early Market
	Kg.	*Kg.*	*Kg.*
1	2.78	2.82	3.48
2	2.28	3.01	3.74
3	2.51	1.69	3.16
4	2.56	1.87	2.98
5	2.20	1.64	2.25
Mean	2.46±0.06	2.21±0.17	3.12±0.15
Standard deviation	0.21±0.04	0.58±0.12	0.51±0.11
Coefficient of variability	8.53±1.82	26.24±5.94	16.34±3.47
Computed yield per hectare	4,100	3,683.3	5,200
Relative yield	100%	89.8%	126.8%

[1] Each row was 12 meters long or equivalent to 6 sq. meters.

TABLE 5.—*Comparative yields of the two best-yielding cauliflower varieties under local conditions*

Plot number [1]	Early Patna	Early Market
	Kg.	*Kg.*
1	4.42	8.04
2	4.49	5.90
3	4.77	5.75
4	4.03	4.01
5	5.66	6.46
6	5.67	6.98
7	5.43	5.20
8	3.40	5.79
Mean	4.73±0.18	6.01±0.26
Standard deviation	0.76±0.13	1.12±0.18
Coefficient of variability	16.17±3.57	18.63±4.53
Yield per hectare	4,457.1	5,723.8
Per cent heading	96.8	97.6

[1] The plot had an area of 10.5 sq. m. (1 x 10.5 m.)

1937–1938 test.—This culture included seven varieties, four of which were newly introduced. The summary of the results of this study is presented in table 6.

TABLE 6.—*Results of the cauliflower test during the 1937–1938 season* [1]

Variety name	Heading	Mean yield [2]	Computed yield per hectare	Relative yield
	Per cent	*Kg.*	*Kg.*	*Per cent*
Early Patna	80	1.95±0.15	4,875	100
Early Market	100	3.78±0.09	9,450	193.8
Early Benares	71.7	1.64±0.17	4,100	84.1
Burpeana	13.4	0.30±0.01	750	15.4
Burpee's Fordhook	0			
Burpee's Ideal Snowball	13.4	0.17±0.01	422	8.7
Dry Weather	13.4	0.13±0.01	322	6.6

[1] Mr. A. L. Tecson of the Horticulture Section assisted in conducting this test.
[2] Average of 2 to 4 replications.

1938–1939 culture.—Eight varieties were cultured in this test, two of which were tested here for the first time. Table 7 presents the summary results of this test while table 8 is a summary of tables 2, 3, 4, 5, 6, and 7.

TABLE 7.—*Results of the 1938–1939 cauliflower acclimatization test*[1]

Variety name	Heading	Average weight per head	Computed yield per hectare[2]
	Per cent	*Gm.*	*Kg.*
Burpeana	0		
Dry Weather	0		
Early Benares	51	197.95±10.72	2,804
Early Italian Giant	0		
Early Market	82	165.50 ± 9.90	3,770
Early Patna	78	198.10± 8.47	4,292
Early Snowball	0		
Burpee's Ideal Snowball	0		
Large Algiers	0		

[1] Mr. J. M. Ilagan of the Horticulture Section assisted in conducting this test.
[2] The yield per Ha. was computed on the basis of 27,777 plants per Ha.

TABLE 8.—*Average yields per hectare of different varieties of cauliflower (Summary of tables 2, 3, 4, 5, 6, and 7)*

Variety name	Number of tests made	Days to maturity	Heading	Yield per hectare	Relative yields
			Per cent	*Kg.*	*Per cent*
Early Patna (Standard)	8	81–110	84.9	3,971	100
Early Benares	7	88–113	67 8	2,718	73
Maincrop Patna	3	94–120	31.5	1,359	32
Maincrop Benares	3		0		
Henderson's Primosnow	1		0		
Henderson's Snowball	1		0		
Sutton's All the Year Round	1		0		
Sutton's Improved Snowball	1		0		
Sutton's White Queen	1		0		
Chinese	2		0		
Merveille de Tout Saison	1	77 113	66.2	587	15
Early Market	5	82–106	94.7	5,366	133
Burpeana	2	132–133	6.7	375	9
Burpee's Fordhook	1		0		
Burpee's Ideal Snowball	2	104–108	6.7	211	5
Dry Weather	2	105–116	6.7	161	4
Early Italian Giant	1		0		
Early Snowball	1		0		
Large Algiers	1		0		

DISCUSSION OF RESULTS

The results of this study brought out some information that should prove interesting and valuable, not only to gardeners in the Islands, but also to those who are interested in the improvement and development of the local vegetable industry. All the varieties tested produced normal and healthy plants, but they greatly differed in their ability to produce curd, or head.

1934–1935 cultures.—During the 1934–1935 vegetable season, nine varieties were tested, four of which having been subjected to two or more tests made in different months. Of these nine varieties, two produced heads. These were Early Benares and Maincrop Patna; they both produced heads in all the three sets of cultures. Early Benares had a heading percentage of from 56.3 to 75.9, while Maincrop Patna gave a heading of from 15.5 to 46.0 per cent. Early Benares produced bigger and better heads but these were not as good as those of the Early Patna.

The other varieties tested failed to produce any head in spite of their good vegetative development. With respect to this, special mention may be made of Sutton's All the Year Round, which had a very good vegetative development. The plants of this variety were of medium size but very uniform, low, stocky, with broad and numerous leaves—all these being suggestive of big, compact, and well-protected heads. This variety, however, failed to produce any head.

1935–1936 test.—With the two heading varieties in the previous season, two new ones were included in this year's culture. These were Merveille de Tout Saison, a variety claimed to have been bred to suit Kuala Lumpur (Federated Malay States) conditions [1], and Early Market, a new introduction from India. Both of these varieties produced heads, the former registering 66.2 per cent heading and the latter giving 96.3 per cent heading. Early Market gave a much higher yield of head per unit area than did Merveille de Tout Saison. In fact, Early Market gave the highest yield in this culture, even outyielding Early Patna by over 70 per cent (table 3).

1936–1937 tests.—A more thorough comparison of the yielding power of the three best varieties so far found, namely, Early Patna, Early Benares, and Early Market was made. As seen in table 4, Early Market was the heaviest yielder, followed by Early Patna, and Early Benares was the poorest. The corresponding yields of 12-meter rows of these varieties were 3.12 ± 0.15, 2.46 ± 0.06, and 2.21 ± 0.17 kilograms, respectively. In table 5, it is again shown that Early Market gave a decidedly greater yield per unit area than did Early Patna, their respective yields per hectare being 5,723.8 and 4,457.1 kilograms. However, the heads of the Early Patna seemed to be more

[1] From a letter of S. M. Sharma, filed with the records of the Bureau of Plant Industry.

uniform in size than those of the Early Market, as shown by their respective coefficients of variability (tables 4 and 5).

1937–1938 culture.—As seen in table 6, three of the new varieties tested produced some heads, namely, Burpeana, Burpee's Ideal Snowball, and Dry Weather. The percentage of heading of these varieties, however, was very low and the heads were small and had the objectionable "ricy" appearance. On the other hand, Early Market, Early Patna, and Early Benares gave good yields as in previous tests, their respective yields in this test being 9,450, 4,875, and 4,100 kilograms per hectare.

1938–1939 culture.—This test, which included nine varieties, did not reveal any new finds. On the other hand, such varieties like Dry Weather, Burpeana, and Burpee's Ideal Snowball, which produced some heads in the 1937-1938 culture, failed to show any sign of curding this season. Also, unlike in previous tests, Early Patna outyielded Early Market in this test. Early Benares remained third. The corresponding yields of these varieties as computed on the basis of one hectare were 4,292, 3,770, and 2,804 kilograms.

PROMISING VARIETIES

Table 8 presents a summary of the performances of the 18 varieties tested. Of these, seven varieties were able to produce some heads, but only two, namely, Early Market and Early Benares, are considered promising and would be worthwhile growing at low altitudes. The computed average yields per hectare of these varieties, as based on from 5 to 7 cultures, were 5,366 and 2,718 kilograms, respectively as compared with the 3,971 kilograms of the standard variety, Early Patna (table 8). The respective average per cent headings were 94.7, 67.8, and 84.9. Early Market was ready for harvesting in from 82 to 106 days after sowing; Early Patna, from 81 to 110 days; and Early Benares, from 88 to 113 days.

Early Market, Early Patna, and Early Benares, even to one who is quite familiar with them, would appear practically similar. Early Benares is a wee bit taller than either Early Market or Early Patna, but the last two varieties have the tendency to produce wider leaves. As a rule, however, these three varieties did not seem to be in a high degree of purity. The plants showed great variability in size, development, and maturity. The heads they produced were also very variable in size and in compactness, especially those of Early Benares. Unless the soil is very fertile, the plants, being early maturing, are apt to

ıead even if they are still small and have few leaves. In this ;ase, the heads are also small, and do not have the milky white ıppearance which is desired in the market. In order to obtain ;ood results, the seedlings should be raised in fertile seedbeds ;o that they could be transplanted within a period of four veeks. Then the field should be well supplied with thoroughly lecayed stable manure or compost and properly supplemented vith some commercial fertilizers.

SUMMARY

This study was undertaken during a period of five vegetable ;easons, 1934 to 1939 inclusive. A total of 19 varieties (in-;luding Early Patna which was used as the standard) has been ;ested, and each of these was cultured from one to eight times.

Of the 18 new varieties tested, seven were able to produce ;ome heads. These varieties are Early Benares, Maincrop Pat-ıa, Merveille de Tout Saison, Early Market, Burpeana, Dry Weather, and Burpee's Ideal Snowball. The average yields of ;hese varieties varied from 161 to 5,366 kilograms per hectare, ınd the period of maturity (from sowing to harvesting) was ;rom 77 to 133 days.

Of the seven varieties that produced heads, only two were ound to compare favorably with the standard (Early Patna). ;hese two varieties are Early Market and Early Benares. Until ve can produce better varieties, Early Market and Early Be-ıares, together with Early Patna, will constitute the commercial ;arieties of cauliflower for the lowlands in the Philippines.

Compared with Early Patna, Early Market outyielded the ormer by 33 per cent, while Early Benares was outyielded by the tandard variety (Early Patna) by 27 per cent. Early Market ;ave an average yield of 5,366 kilograms per hectare based on ıve cultures; Early Patna, 3,971 kilograms as average of eight ultures; and Early Benares, 2,718 kilograms as average of even cultures. Early Market gave an average heading of 94.7 ;er cent; Early Patna, 84.9 per cent; and Early Benares, 67.8 ;er cent.

ILLUSTRATIONS

Plate 1

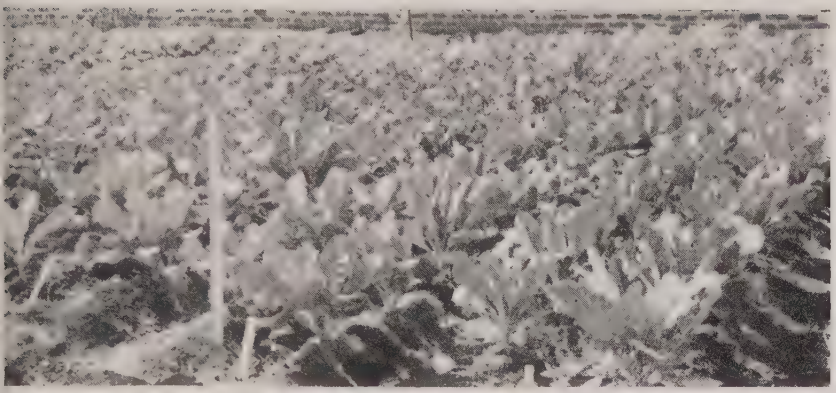
Fig. 1. A portion of the acclimatization test field (1938–1939) at the Central Experiment Station, Manila.

2. Cauliflower acclimatization plots at the La Union Provincial Nursery, Bangar, La Union.

Plate 2

Fig. 1. A well-formed head (curd) of Early Patna.

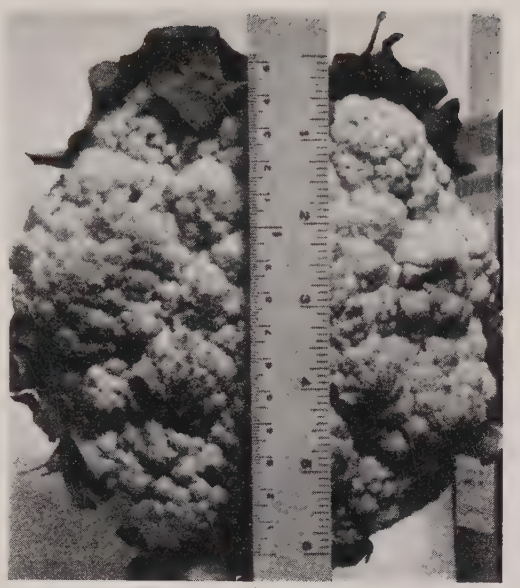
2. A well-formed head (curd) of Early Market.



1

2

PLATE 1.



1

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PLATE 2.

A NEW PHYTOPHAGOUS LADY BEETLE IN THE PHILIPPINES

By Salustiano S. Gonzales

Of the Plant Pest and Disease Control Division
Bureau of Plant Industry

THREE PLATES

The Governor's plum or cerali, *Flacourtia indica* (Burm. f.) Merr., in the Los Baños Economic Garden, has, for some time, been seriously defoliated by a species of coccinellid beetle which, according to Dr. Fritz van Emden of the Imperial Institute of Entomology, London, England, in a letter to the writer dated January 10, 1939, is *Plagiodera metallica* Er. As far as the writer is aware, this is the first time that this species is reported in the Philippines as a pest. Both larvae and adults feed considerably on the leaves of cerali. No other hosts are so far known.

LIFE HISTORY, HABITS, AND DESCRIPTIONS

The eggs (plate 1, fig. 1) are elongatedly subovoid and greenish-yellow when newly laid. They, however, turn yellow when about to hatch. They measure about 1 millimeter long and 0.4 millimeter in cross-section. The eggs are invariably laid on either surface of the young leaves of the host plant either singly or in groups of from 2 to 27. It was observed that ovipositions took place at night. The incubation period was found to be about 3 days.

There are three instars. When newly hatched (plate 1, fig. 2), the larvae are light greenish-yellow. They measure about 1 millimeter long and 0.6 millimeter wide. The head and the pronotum are dark brown, approaching black. The legs are of the same color as the body, with dark brown joints. A pair of dark brown or black circular rings, the centers of which are of the same color as the rest of the body, is present on each side of the last two thoracic segments. There is a row of dark brown dots along the length of each side of the abdomen. Three

thoracic and nine abdominal segments were counted. The body is sparsely beset with short firm hairs. The mature larvae (plate 1, fig. 3) vary in color, from dark brown to black. They measure from 5 to 6 millimeters long and from 2.5 to 3 millimeters wide.

When newly hatched, the larvae stay together most of the time, usually on the nether surface of the young leaves. During this stage, they are very slow feeders, nibbling the leaves on the edges and producing irregular cuts along the margin. As they grow older, however, they begin to spread and gradually become voracious until they consume the entire leaves and cause the trees to appear bare (plates 2 and 3). Feeding takes place day and night. The larval stage is about 6 days.

Pupation takes place on the leaves or twigs of the host. The pupa (plate 1, fig. 4) is broadly suboblong when viewed from the top. It measures about 4 millimeters long and 3.2 millimeters wide. It is dorsally convex and slightly bent ventrally. It is ochre-brown, lighter ventrally. The exuvia of the last larval instar is attached to the posterior end of the body of the pupa and this, in turn, is securely attached to the plant. The pupal stage lasts for from 3 to 4 days.

The adult (plate 1, fig. 5) is a beautiful metallic black lady beetle measuring from 4.5 to 5 millimeters long and from 4 to 4.5 millimeters wide. The males are generally smaller than the females. They feed on both the young and the old leaves of the host. They live for from 10 to 40 days under laboratory conditions. These beetles can also sustain hunger, as evidenced by the fact that beetles in confinement in our laboratory cages were noticed to be still alive after one week without food.

CONTROL MEASURES

The following control measures are being adopted with gratifying results:

1. Collection of the insect in all its stages.
2. Spraying with soap solution at the rate of 16 to 25 level tablespoonfuls of powdered soap per petroleum canful of water. This concentration kills both larvae and pupae.
3. Spraying with lead or calcium arsenate at the rate of from 8 to 10 level tablespoonfuls for every petroleum canful of water.

ILLUSTRATIONS

PLATE 1

Life history of *Plagiodera metallica* Er.

FIG. 1. Egg. X 20.
2. Larva, first instar. X 20.
3. Larva, third instar. X 10.
4. Pupa, ventral view. X 10.
5. Adult, dorsal view. X 10.

PLATE 2

A *Flacourtia* tree completely defoliated by the lady beetles.

PLATE 3

Another *Flacourtia* tree partially defoliated by the lady beetles.

1

2

3

4

5

PLATE 1.

PLATE 2.

PLATE 3.

RICE DISEASES AND METHODS OF CONTROL[1]

By GAUDENCIO M. REYES

Plant Pathologist, Bureau of Plant Industry

FIFTEEN PLATES

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INTRODUCTION

There are several diseases attacking rice in the Philippines; some are of widespread occurrence while others are of limited distribution. Considering the scattered areas devoted to rice cultivation under varying sets of conditions and the fact that these diseases have complete freedom to multiply and spread far and wide, their actual distribution is much wider than is already known. Also, on account of the fact that rice in the Philippines grows under two distinct sets of conditions, nature has provided some means whereby the ravages from diseases are delimited. In order, however, to know clearly which diseases are actually doing more or less serious damage, and owing to the size of the industry, a yearly systematic survey of rice diseases seems necessary before we can evaluate their importance as they occur in the field. For the same reason, it is difficult to estimate with any accuracy the losses due to specific rice diseases or rice diseases taken as a whole. It is only

[1] Farmers' Circular No. 50.

safe to say, however, that they cause the loss of thousands of cavans every year. Conservatively speaking, diseases can reduce the rice crop in the Philippines by at least five per cent. Present knowledge leads us to believe that some diseases are potentially more important than others; while some may appear annually in epidemic form, others cause only sporadic outbreaks.

Rice, like other plants, may fall victim to other destructive elements without being attacked by fungus or bacterial organisms. For example, lack of water or too much water are equally detrimental to rice. Lack or excess of certain food elements are no less harmful to the rice crop. Storms and floods have caused heavy damage to rice in the Philippines many a time. Salt water and acid soil are also injurious to the rice crop. There are also other causes which, of course, find no place in this discussion.

While a thorough knowledge of the symptoms and causes of rice diseases, the conditions favoring them, methods of dissemination, etc., is the first essential asset before appreciating their methods of control, much damage can be averted by the use of clean, healthy seeds and improved cultural treatment. The most persevering worker would often lose his way if he fails to get a thorough understanding of his disease problem. This basic knowledge is very important to every rice grower, and to emerge triumphant over all possible odds "every grower must in practice be his own rice doctor." By the very nature of conditions existing in the Philippines, especially with reference to rice, the ultimate solution of our control problem seems to lie largely in immunization. On account, however, of the long and arduous task confronting a single investigator of developing resistant varieties possessing desirable agronomic and commercial traits, a great deal more still remains to be done before we can hope to see our rice crops reasonably free from the maladies generally known to be inflicting enormous damage yearly. In the absence of a thorough knowledge of the varieties or strains that can withstand the effects of various diseases extant, we must content ourselves with the available methods in vogue, even though some of them are rather expensive and can only do partial wonders. But whichever expedient method or methods are employed, the degree of success would depend in no little measure upon the community spirit.

For combating the diseases of rice in the Philippines, this illustrated treatise has been prepared as a matter of expediency

to help those who may be engaged in this kind of work, in accordance, more or less, with the order or time of the year in which the diseases generally appear. At times, however, two or more diseases may occur simultaneously, doing damage conjointly although in unequal proportions, thus aggravating a disease situation.

SEED-BORNE DISEASES

Some rice diseases are often carried on or within the seed, some of which produce various shades of discoloration on the glumes. The most common parasitic fungous diseases carried by the seed are the Fusarium (plate 1), the Helminthosporium (plate 4), the black smut (plate 10), the Piricularia, the Cercospora, and the green smut (plate 13). Upon the ability of the farmer to detect diseased seeds depend in some measure the safeguards against the introduction or multiplication of diseases in his own field. If no clean, healthy seeds are available, much trouble can be averted by resorting to the use of seed treatments.

Control.—Shocking while damp would stimulate the growth of seed-borne organisms—not only those that can cause disease but also those that are nonpathogenic. Healthy seeds of known source should be used. Diseased seeds should not be mixed with sound seeds and no seeds should be stored when not properly dried. If no sound seeds are available, disinfection should be resorted to. The hot-water treatment is recommended as a cheap method. Soak the seeds in half-filled bags, tied at the top overnight in cold water. Remove and drain off the water and then dip in hot water at 55° C. for 5 minutes. Dip the bags in cold water to stop the action of the heat and then spread out to dry thoroughly, or sow the seeds. This method is effective for both external and internal seed-borne diseases.

Likewise, for internal seed diseases, the following method [1] is used, but this is only feasible on a small scale and is recommendable for experimental purposes. Soak the seeds in water overnight. Immerse for 2 to 5 minutes in 50 per cent alcohol containing 2 grams of mercuric chloride in each 1,000 cc. and shake. Use plugged, wide-mouthed bottles. Pour off the mercuric chloride solution and wash the seeds once with 93 per cent alcohol. Then wash them with clean or sterile water three times.

For spores adhering to the outside of the grain, the procedure to be followed is to soak seeds in clean water for six hours or

[1] After the method used for other cereals by C. C. Chen, Bulletin 240, Maryland Agricultural Experiment Station, 1920.

overnight. Drain off the water and then immerse in 1:1,000 mercuric chloride solution for 30 minutes. Then wash thoroughly with clean water three times. In disinfecting rice seeds, it is always advantageous to float and skim off all light grains first before proceeding in the use of any treatment. This will remove chaffy or infected grains as well as foreign materials, and will save any extra outlay for fungicides or for more seeds to the hectare due to decreased rate of germination and perhaps for re-sowing.

Chemical treatments by dusting or dipping are prescribed elsewhere under certain specific cases.

DISEASES OF MAJOR IMPORTANCE

SCLEROTIUM DISEASE

The sclerotium disease attacks both young and old rice plants. Blighting caused by this disease generally occurs in seedbeds. Sometimes it may also attack older plants where there is no standing water when a damp, hot weather obtains. In moist soil, under this weather condition, upland rice is also subject to its attack. It causes stunting and blighting of seedlings or yellowing of older plants in patches caused by a cosmopolitan soil-borne organism, *Sclerotium rolfsii* Sacc. White mats of tufted vegetative growth and white to brown sclerotial bodies or compact balls of fungous threads (resting stage of the fungus) may be seen on the ground, or attached to the base of the stem. These sclerotial bodies serve as a means of propagating the disease and perpetuating the species.

Control.—As soon as the disease is noticed in seedbeds, all plants, including the soil in the infested areas to a depth of six inches or more towards the belt of surrounding healthy plants, should be removed to prevent further damage. The irrigation water should be allowed to accumulate in the hole or excavated area. If water is plentiful, submerge temporarily all surface areas, but never allow it to pass through diseased areas. Thick planting or weedy culture is very conducive to the growth and progress of the disease and, therefore, it should be avoided. Cultivation, whenever possible, especially in upland rice culture, would check the progress and spread of the fungus.

It is not advisable to use for seedbed any place where the disease is known to have occurred in the previous season. In case no other land is available, which is unlikely to happen, chemical treatment of the soil may be used in severe infections as a last recourse. After the harvest, the land intended for seed-

bed should be plowed to break the continuity of the fungous threads and to admit plenty of aëration and sunlight. A month before sowing, the plowed-infested land should be crushed fine and then treated with bluestone solution (1 lb. copper sulphate to 7 gallons of water), or with 3 per cent commercial formalin at the rate of 2 liters of solution per square foot of soil.

HELMINTHOSPORIOSE

The helminthosporium disease, being seed-borne, is a frequent source of material damage to rice seedbeds causing blighting. When transplanted, the infected seedlings generally produce diseased plants and may spread rapidly to other plants or fields. The disease appears on the leaves as small, brown, oval or elliptical spots (plate 2), and as dark-brown elongated lesions oftentimes formed in bands around the stem at the seedling stage. On older plants (plate 3), the spots on the foliage are generally larger, semicircular or elliptical, with brownish or grayish centers and more definitely brown borders, and each spot has a yellow or orange zone around. They are visible on both surfaces and some run together, causing premature drying of the leaves. In the center of old spots, black felty masses of the causal organism are often visible. On the glumes (plate 4) and sheaths, it produces a brownish-black discoloration covered by velvety masses of black fungous growths. On or about the lowest joint of the rachis, and at the sheath-nodes, black velvety growths of the fungus may also be seen. The causal fungus is *Helminthosporium oryzae* van Breda de Haan. This disease attacks both upland and lowland rice, but it appears to be more injurious to the former than to the latter. It causes a reduction both in the quality and quantity of the produce.

Control.—For diseased seed, the control measure which is recommended is the hot-water treatment described elsewhere. This method is known to give satisfactory control, but sometimes secondary infection takes place. No chemical treatment has yet been found to completely rid seeds of vegetative parts of *Helminthosporium oryzae*. As the disease is seed-borne, selection of healthy seeds is very important. Only healthy seedlings should be transplanted. Clean culture is a necessary concomitant because the causal fungus has been reported to occur on a number of grasses. Sanitary measures will help greatly in reducing sources of infection in the field by burning all infected plants. Certain varieties like Dumali, Khao Bai Sri, Macan China, and Elonram, for examples, are very sus-

ceptible to the disease, while Elon-elon, Sipot, and Apostol are quite resistant varieties. Fertilization or liming of the soil would probably minimize greatly damage caused by this disease, it having been observed that the disease becomes more serious on weakened or partly starved plants, and less so on border plants.

BLAST

Rice blast and rotten-neck are synonymous. Blast is claimed by previous investigators abroad to be the most serious of rice diseases. Fortunately its known outbreaks in the Philippines have been quite sporadic, occurring at some intervals of time. Reports of initial outbreaks of the disease have been confirmed so far by the writer only in the provinces of Rizal, Laguna, Davao, Abra, and Nueva Ecija. Once a loss of about 25 per cent has been fairly estimated in a threatening outbreak in a comparatively newly opened land, but how the disease originated was largely a matter of conjecture.

The more usual manifestation of the disease in the Philippines is the rotten-neck, characterized by the elongated grayish or straw-colored lesion with a dark-brown border, produced around the neck region (plate 5) below the lowest node of the rachis or common axis of the head. As a result of this infection, there is shortening of the heads which are either partially filled or completely sterile. When, however, the infection takes place when the panicles are about to fill, they generally break over and, by the force of the wind or during harvest, some of them may fall off.

The leaf-spot form produced by the same disease may also be observed, but this seldom occurs. Young spots are uniformly water-soaked with yellowish borders, while older spots are quite irregular in size and shape, having a water-soaked, greenish-gray or ashen centers with dark reddish-brown borders. The old spots look somewhat like the eyespot of sugar cane.

The disease is caused by a virulent parasite, *Piricularia oryzae* Br. et Cav., which can be easily spread by the wind or introduced with the seed, especially that obtained from infested places or countries, particularly in the Orient. Its serious prevalence is greatly dependent on weather conditions, and upland rice seems to be more seriously affected by it than lowland rice. Buluhan, Inintiw, Mestiza, and Matungga are four susceptible varieties.

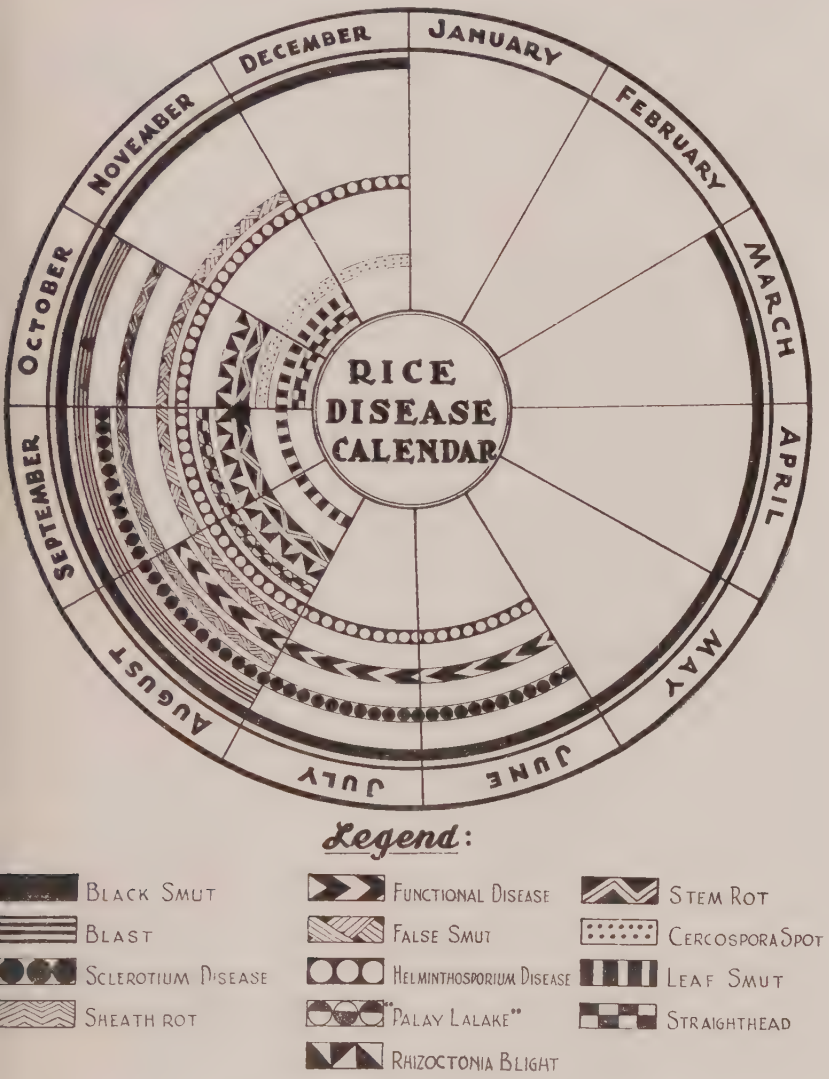

Fig. 1.

Control.—The most effective measure for the control of this disease is local quarantine, i. e., prohibition of seed distribution from infested areas. Complete destruction by burning of all sources of infection, such as the stubble, straw, husks, and eradication of weed hosts are also beneficial measures to take. On account of its liability to occur in epidemic form, the mechanical dissemination of the disease should be guarded against. The use of seeds from disease-free fields is advisable. In case of

persistent attacks, crop rotation may be employed as an extreme measure. Owing to the disastrous nature of this disease no efforts should be spared to stamp it out upon its inception in a locality or region. Field observations seem to indicate the possibility of discovering or developing varieties of rice possessing some resistance to blast.

"PALAY LALAKE"

This is a comparatively new disease which is fast gaining a foothold in some lowland rice districts and is, therefore, of increasing economic importance. It generally appears a month or so after transplanting. It is very conspicuous in the field by the narrow, light-green leaves and by the lanky growth of the affected plants, especially in fields where the plants are darker green than normal. In advanced stages a luxuriant growth of pinkish-white fungus, a species of *Fusarium*, may be seen accumulating externally on the stem above the water surface, especially at the nodal regions (plate 6).

Control.—The most important step towards its eradication is to rogue out the diseased plants as soon as noticed. Sanitation is equally an important adjunct, otherwise the foci of infection would be hard to eliminate. Its mechanical distribution should be guarded against. Burying of fresh infected plants, burning of the stubble, and the plowing of diseased fields after harvest should not be overlooked. These would rid the field of infectious materials inimical to the following rice crop. Plowing would hasten the drying of the fungus present in the soil.

Rice for seed should never be secured from diseased fields. Macan Bino, Apostol, Macan Biñan, and Guinangang strain 1 were found to possess some degree of resistance to the disease, while Macan 1, Macan Tago, Ramay (Ramai),[2] and Magcumpol are susceptible varieties.

STEM ROT

The stem rot is probably the most widely known of all rice diseases, causing at times damage of great proportions in some parts of the Philippines. Reports of its occurrence have been confirmed both in the Visayas and in Luzon under lowland conditions. It generally appears late in the season, attacking rice

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[2] Studies on the morphological and physiological differences of the two varieties are in progress. Editor.

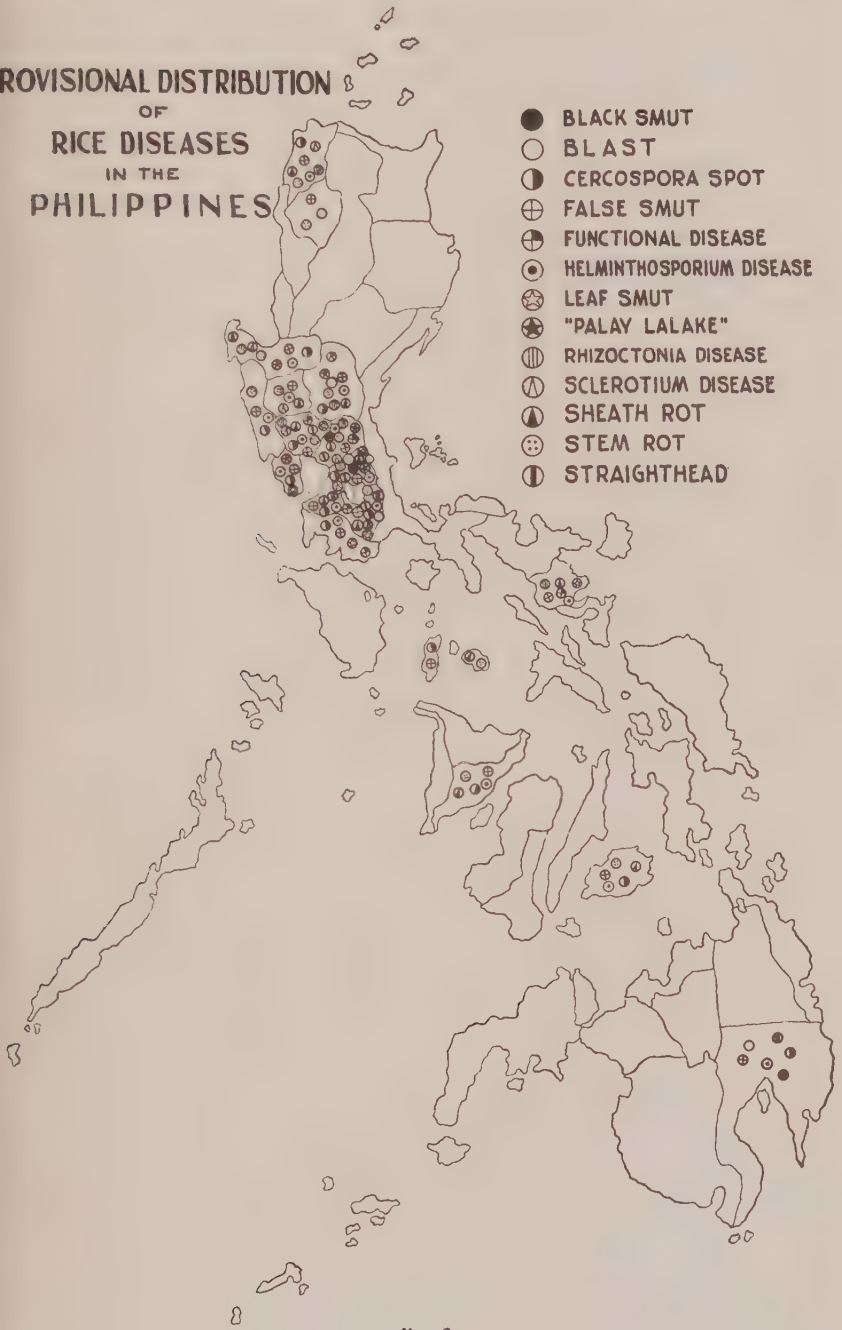

ROVISIONAL DISTRIBUTION
OF
RICE DISEASES
IN THE
PHILIPPINES
BLACK SMUT
BLAST
CERCOSPORA SPOT
FALSE SMUT
FUNCTIONAL DISEASE
HELMINTHOSPORIUM DISEASE
LEAF SMUT
"PALAY LALAKE"
RHIZOCTONIA DISEASE
SCLEROTIUM DISEASE
SHEATH ROT
STEM ROT
STRAIGHTHEAD

FIG. 2.

plants at the water level, causing brownish-black elongated lesions at the base of the stem, yellowing and then browning of the leaves, and finally a more or less complete decay of the stem tissues. As a consequence of severe infection, lodging may take place. When the disease attacks the plant at an earlier stage, partial or complete sterility of the panicles may result. Inside the diseased stem are lodged numerous spherical, shiny, black sclerotia and dense mats of ashen fungous threads (plate 7). The fungus responsible for this disease is *Leptosphaeria salvinii* Catt. (= *Sclerotium oryzae* Catt.).

Control.—The disease may be checked by draining the water from the newly infected fields for a few weeks or until the plants show signs of recovery before watering again. During the intervening time, however, the land must be kept just wet, and never allowed to crack up. Sanitary measures should be observed, such as the avoidance of scattering infected plants and soil. The irrigation water should not be allowed to flow from, or pass through, a diseased area to a disease-free one because the sclerotia of the fungus are capable of floating and may cause further damage upon contact with healthy plants. Burn all diseased stubble and straw *in situ* as soon as practicable so as to destroy the seats of infection and at the same time heat the surface soil. The substitution of resistant varieties, such as Elon-elon, Ramay (Ramai), Macan Biñan, and Raminad strain 3 for susceptible varieties is recommended in badly diseased localities, for it generally gives more lasting results.

SHEATH ROT

The sheath rot is another sclerotial disease of lowland rice. It causes yellowing and subsequent drying of the outer leaves through the infection of the leaf sheaths (plate 8) by the production of dark-brown lesions. Although the ravages of the disease are generally confined to the leaf sheaths of maturing plants, those attacked are very much weakened and as a consequence the yield is considerably reduced. Occasionally the causal fungus penetrates through the harder tissues of the stem. Close planting and stagnant water are conducive to the development of the disease, and readily lodged plants or varieties fall easy victim to it.

The causal organism is *Sclerotium sphaeroides* Nak., and the sclerotia, which are white when young and dark brown when old, are produced on (plate 8), or within, the sheaths, but seldom inside the culm. Masses of fungous threads may be seen also lodged in the cells of the sheaths and sometimes, but rarely, in

the hollow of the stem. The mature sclerotia have a somewhat rough surface and are irregularly shaped, simulating more closely the characteristics of *Sclerotium rolfsii* rather than those of *S. oryzae*. They are capable of floating and may develop on buoyant plant debris.

Control.—This disease is amenable to the control measures recommended for stem rot. Field observations seem to show that the strong-stemmed varieties like Macan Biñan, Kinatuday, Guinangang strain 1, and Ramay (Ramai) are less affected by the disease. The selection of resistant varieties apparently offers the best means of control.

RHIZOCTONIA BLIGHT

Rhizoctonia blight is caused by a fungus (*Rhizoctonia solani* Kühn.) that is common and attacks both seedling and maturing rice in low and poorly ventilated fields. It is an aggressive parasite under high temperature and moisture conditions. The attacked plants show irregular blotches of a variegated hue, with brown borders on the leaves and sheaths (plate 9). These characteristics are symptomatic of premature death. On these blotches, large, white to brown, irregularly shaped sclerotia may be seen adhering. Most of the affected plants remain erect and the grains fail to fill; some heads do not emerge at all, simulating very much a straighthead affection. Thick planting and nitrogenous fertilizers favor the development of the disease. Inadhica, Macan, and Sipot are susceptible varieties.

This fungus has also a variety of grass hosts, common neighbors, from which it passes to rice. The most common of these rice weeds are kolatay [*Cynodon dactylon* (Linn.) Pers.], muthá (*Cyperus rotundus* Linn.), bulang (*Panicum colonum* Linn.), and luyaluyáhan (*Panicum repens* Linn.). In addition to rice, it attacks other crops as well, such as wheat, corn, sugar cane, and soy bean.

Control.—Keeping the diseased field well watered for considerable periods would probably destroy the resting stage of the fungus and prevent its rapid spread. Thick planting should be avoided, especially in areas subject to the disease. Piling and burning of the plant trash to heat the surface soil, and plowing of the infested field after harvest are beneficial measures in eliminating as much as possible the sources of infection.

BLACK SMUT

The black smut, or bunt of rice (plate 10), caused by *Tilletia horrida* Tak. is a disease which is also carried by seeds. It is

systemic in character, affecting the plant from the time the seed germinates up to maturity. At the seedling stage, a few plants may show chlorosis. The affected plants when transplanted are somewhat retarded in growth. Under field conditions, the disease becomes noticeable only when the panicle matures by the presence of powdery black spores usually massed towards the tips of the grains, or by the eking out of the partially consumed kernel by the multiple spores produced inside. The bunted grains are usually lighter in weight and in color. In light-colored varieties, a blackish hue may be visible through the glumes of severely infected grains. Numerous spores produced on and inside the grain may be scattered by various agencies, and serve as potential sources of infection in subsequent crops. This disease causes not only a reduction in the yield, but may also depreciate the quality or lower the market value of rice.

Dry-season (or "palagad") rice culture seems to show more pronounced susceptibility than the regular rice-season culture, and early-maturing varieties show more susceptibility than the late-maturing ones. Sipot and Apostol are two of the most susceptible varieties, and to a lesser extent Guinangang strain 1, while Mancasar strain 3 and Elon-elon are considered resistant varieties.

Control.—The disease may be prevented by using seeds obtained from a healthy crop or from a locality where it does not occur. Care, however, must be taken in handling in order not to contaminate the healthy seed. For various reasons, local quarantine should be applied in infected localities to prevent the development of the disease in larger areas. Whenever possible it is always advantageous to grow the late-maturing resistant sorts in localities subject to black smut infection.

Seed treatment with hot water or with chemicals should be resorted to only where no sound seeds are available. Copper carbonate (56.68 grams of 50 per cent grade to 35.2 liters of rice seed) may be used, using a home-made revolving barrel duster. Soaking the seeds in twenty-five hundredth per cent solution of germisan (an organic mercury compound) for 30 minutes is another method of seed treatment for the black smut.

STRAIGHTHEAD

As the name indicates, plants affected with the disease show panicles that remain green longer than normal heads and stand erect and fail to set seeds (plate 11). The affected plants generally have leaves that are stiffer and darker green than usual,

and the sheaths are close. In rare instances, a chlorotic condition is manifested. Badly affected plants do not head at all, but simply remain sterile. Some show distortion in various ways, such as a shortening of the panicles or a decrease in the size of the grains. Magcumpol, Macan I, and Inadhica are commonly affected by this disease.

This diseased condition is caused by a variety of causes; by unfavorable conditions of environment, such as poor aëration of the soil and continuous submergence of the land. It may also be attributed to a certain fungal disturbance dealt with elsewhere, or to a mealy bug infestation.

Control.—Correcting the above conditions would prove to be beneficial because it would induce better development of roots and would restore normal nutritional activity. The damage caused by the insect should be dealt with differently in accordance with accepted principles not within the scope of this paper.

PHYSIOLOGICAL DISEASES

Diseases of functional or nonparasitic origin are caused by highly alkaline or highly acid soils, or by deficiencies of certain essential elements in the soil. Rice plants suffering from these causes are generally stunted and, while the presence of alkaline water or salt reaction (plate 12) shows stunting and a somewhat pale-green color or chlorotic condition of plants, those affected by acid reaction of the soil show severe retarded growth and yellowing. On the other hand, the lack of nitrogen in the soil, although it causes a general yellowing of the plants, does not hinder them so much in their growth as in the above-cited cases.

The presence of weeds in rice fields is intimately related with the normal nutritional activity of rice, for weeds, by crowding out rice, deprive it of some of its food in solution in the soil as well as moisture and sunlight. Their abundance, as noted in many places, has caused varying reductions in yield of grain and straw, frequently unaccounted for quantitatively.

Control.—Nitrogen starvation is amenable to soil amendments, while injuries arising from the first two cases seem rather remote of amelioration. Application of basic or nitrogenous fertilizers, however, may improve conditions. Soil areas traversed by highly alkaline water or by sulfur springs should not be cultivated to rice. Depending on the degree of acidity of a land, amount of rainfall, and soil structure, liming to restore normal reaction, or slight acidity, may improve conditions appropriate for rice culture. Highly sulfurated soil, however, devoted to this purpose, as found in Calamba, Laguna, should

better be abandoned in order to avoid crop failures and expense. Salt toleration among rice varieties may be developed in lands subject to salt water, as in Nagpili, Batangas Province.

The presence of weeds has also a close physiological relation in that it interferes with the normal growth and development of rice by occupying much space and by stealing food from the soil, which would otherwise be utilized by the rice plant. Weeds should, therefore, be eradicated, because they can materially reduce rice yields. Oftentimes they become sources of infectious diseases to rice and some may serve as intermediary hosts, especially the grasses. The best time to control weeds is before they flower or develop seeds.

MINOR DISEASES

There are several diseases affecting rice that are considered of lesser importance, among which are the green smut, the brown linear spot, the leaf smut, the bacterial leaf stripe, and the tip burn. Some of these are encountered regularly, while others appear only occasionally. However, only those that are of greater importance will be mentioned here.

FALSE SMUT

Although the false or green smut caused by *Ustilaginoidea virens* (Cke.) Tak. (plate 13) is a widespread disease of rice under lowland and upland conditions, it seldom becomes dangerous. Only individual grains are attacked in each panicle, the number ranging from one to sixteen, according to actual counts. Generally, however, one to five infected grains are commonly seen. They are green or orange-green powdery masses and very conspicuous by their size, being much larger than the grains, and may be seen on any part of the head. The lump of fungus projects between the glumes and presses them apart. The appearance of the disease is considered in some localities as an indication of a bumper crop, so practically no attention is paid to it by the farmers. Some varieties like Macan I, Apostol, Ramay (Ramai), Magcumpol and Inadhica are susceptible to this disease.

Control.—In case the disease becomes quite prevalent, which seldom happens, it is advisable to select healthy fields from which to secure seeds. Mechanical sieves, or the like, may be employed to get rid of the enlarged grains from the threshed rice to avoid any possible damage to the milled product. At the same time this step would minimize sources of infection in subsequent crops if no sound seeds are obtainable. The discarded swollen grains should then be burned or buried sufficiently deep

in unused ground. Seeds for planting purposes obtained from this batch may be steeped for 30 minutes in 1:1000 mercuric chloride solution, after having been presoaked in tap water for six hours or overnight and after draining off the surplus water. Then wash the seeds three times with clean water. The seeds may also be dipped in a solution made up of 1 pint (0.473 liter) of formaldehyde to 40 gallons of water (1 gallon = 3.785 liters) for 5 minutes. The treated seeds should then be sown immediately in wet soil.

BROWN LINEAR SPOT

This rice disease affects the leaf, sheath, peduncle, and glume, but it is more commonly considered a leaf spot disease because of the preponderance of the leaf lesions. The spots are brown and linear as the name implies and run lengthwise with the leaf (plate 14). The larger spots have light-brown or brownish-gray centers, and by coalescence they form much elongated lesions. Due to their number the operative leaf area of the maturing plant is very much reduced and this causes a weakening of the plant. Because of their great number, they also cause yellowing and hasten the drying of the leaves. The disease is caused by *Cercospora oryzae* Miy.

Control.—Varieties differ widely in their behavior to this disease. For example, it is very serious on Inadhica, but Ramay is less affected by it. The product of a cross between these two parent varieties [Ramay (Ramai) × Inadhica] yielded a highly resistant hybrid—Raminad strain 3. Mancasar strain 3 is another variety possessing considerable resistance, while Elon-elon and Khao Bai Sri are of moderate resistance. The other susceptible varieties are Arabon, Macan I, Magcumpol, Apostol, and Guinangang strain 1. Further observations would probably show a few other varieties not easily subject to its attack; these should be used to supplant the more easily injured varieties.

LEAF SMUT

Leaf smut is found on both lowland and upland varieties. This leaf affection is characterized by the black, small, rectangular spottings running parallel to the veins of the leaf (plate 15). They are slightly raised and visible on both surfaces. The presence of the disease lessens the manufacturing area of the leaf and is, therefore, detrimental to normal growth development. The causal fungus is *Entyloma oryzae* H. & P. Sydow.

Control.—The best method of controlling this disease appears to be the use of resistant varieties. Direct evidence, however, along this direction is still lacking.

ILLUSTRATIONS

PLATE 1
(Slightly enlarged)

Rice seeds severely infected with *Fusarium*, a seed-borne organism.

PLATE 2

Portions of stems and leaves of rice seedlings, showing numerous spots caused by *Helminthosporium oryzae.*

PLATE 3

Leaf spots of maturing rice caused by *Helminthosporium oryzae.*

PLATE 4

Rice heads showing severe infection by *Helminthosporium oryzae.* Note the number of affected, blackened grains.

PLATE 5

Rice panicles affected with rotten-neck (*Piricularia oryzae*). Note the characteristic lesions at the neck region pointed by arrows.

PLATE 6

Basal symptoms on a rice plant affected with "man rice" (a species of *Fusarium*).

PLATE 7

Stem rot of rice, *Leptosphaeria salvinii* (=*Sclerotium oryzae*), enlarged to show internal infection and presence of mycelial threads and numerous shiny, black, spherical sclerotia.

PLATE 8

A sheath-rot-affected rice stool caused by *Sclerotium sphaeroides.* Note the white and dark brown sclerotial bodies formed at the base of the stool.

PLATE 9

Portions of rice leaves and stems showing infection produced by the fungus, *Rhizoctonia solani.* Note the irregularly colored spots on the leaves and sheaths and the sclerotial bodies adhering thereon. Arrows indicate visible sheath lesions.

PLATE 10

Branches of rice heads infected with the black smut (*Tilletia horrida*). Note the ejected kernels (spur-like structures) caused by the multiplication of spores inside the glumes.

PLATE 11

Rice panicles exhibiting the characteristic straighthead affection.

PLATE 12

Rice seedbeds showing the injurious effect of salt water by the loss of normal green color, stunting, and eventual death of the seedlings.

PLATE 13

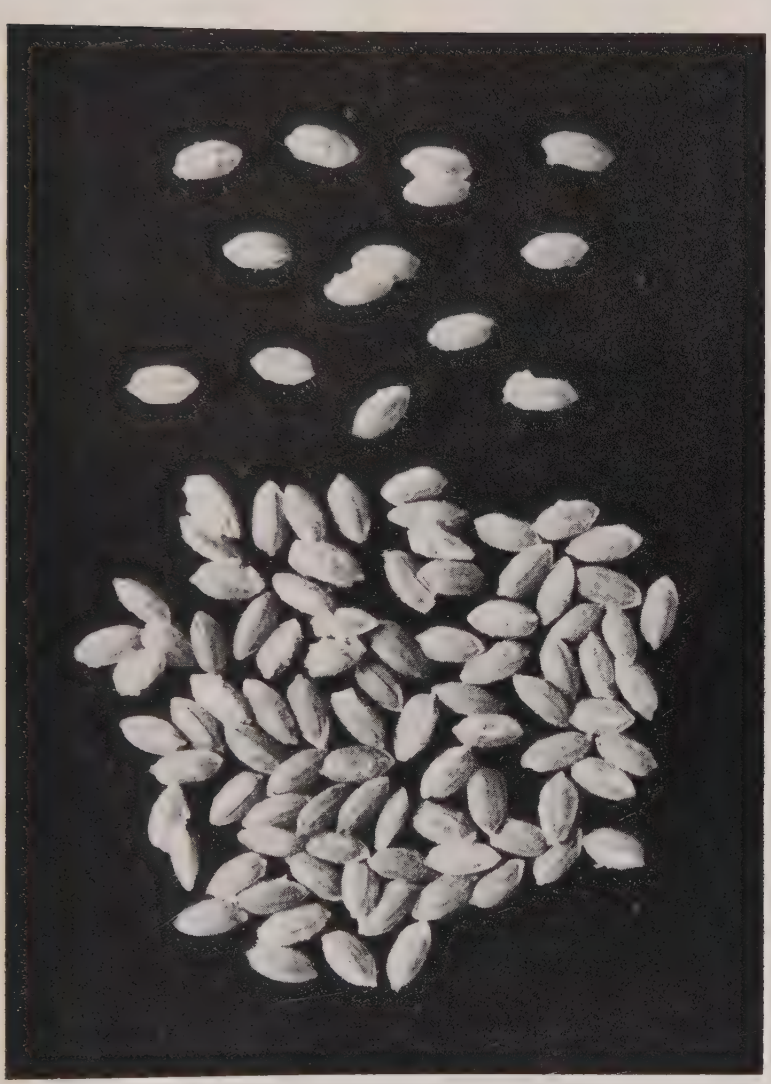
Two rice heads affected with the green smut (*Ustilaginoidea virens*), showing conspicuously the enlarged infected grains.

PLATE 14

Brown linear spot of rice caused by *Cercospora oryzae.*

PLATE 15

Leaf smut of rice (*Entyloma oryzae*). Note the black, rectangular spotting scattered all over.



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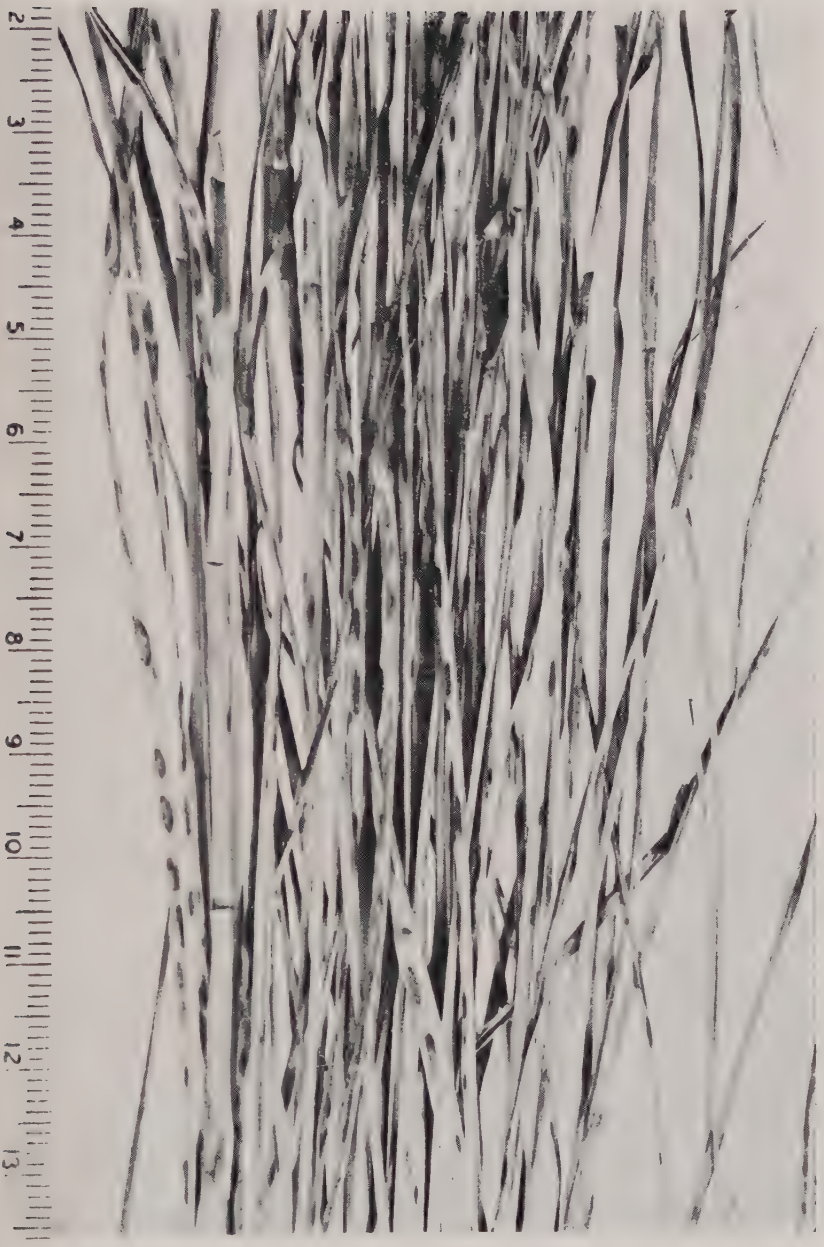

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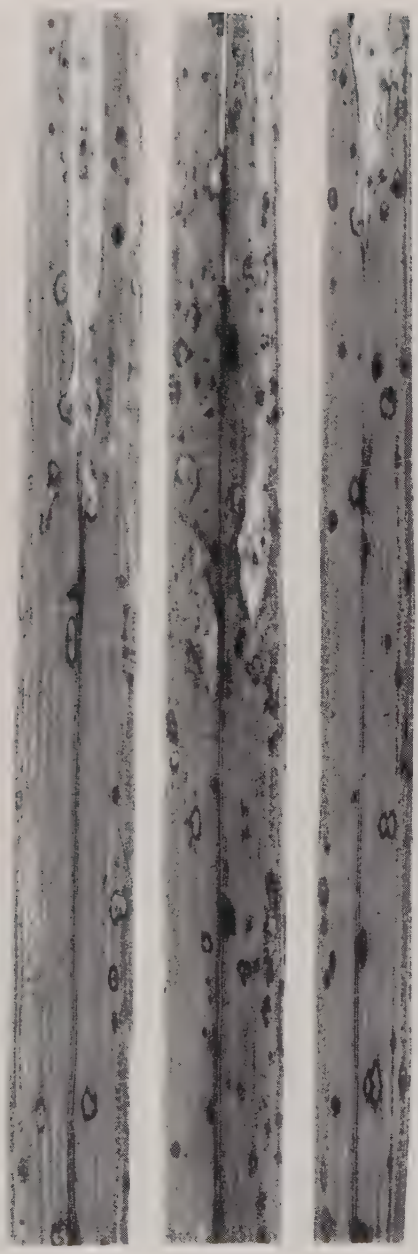

PLATE 3.

PLATE 4.

PLATE 5.

PLATE 6.

PLATE 7.

PLATE 8.

PLATE 9.

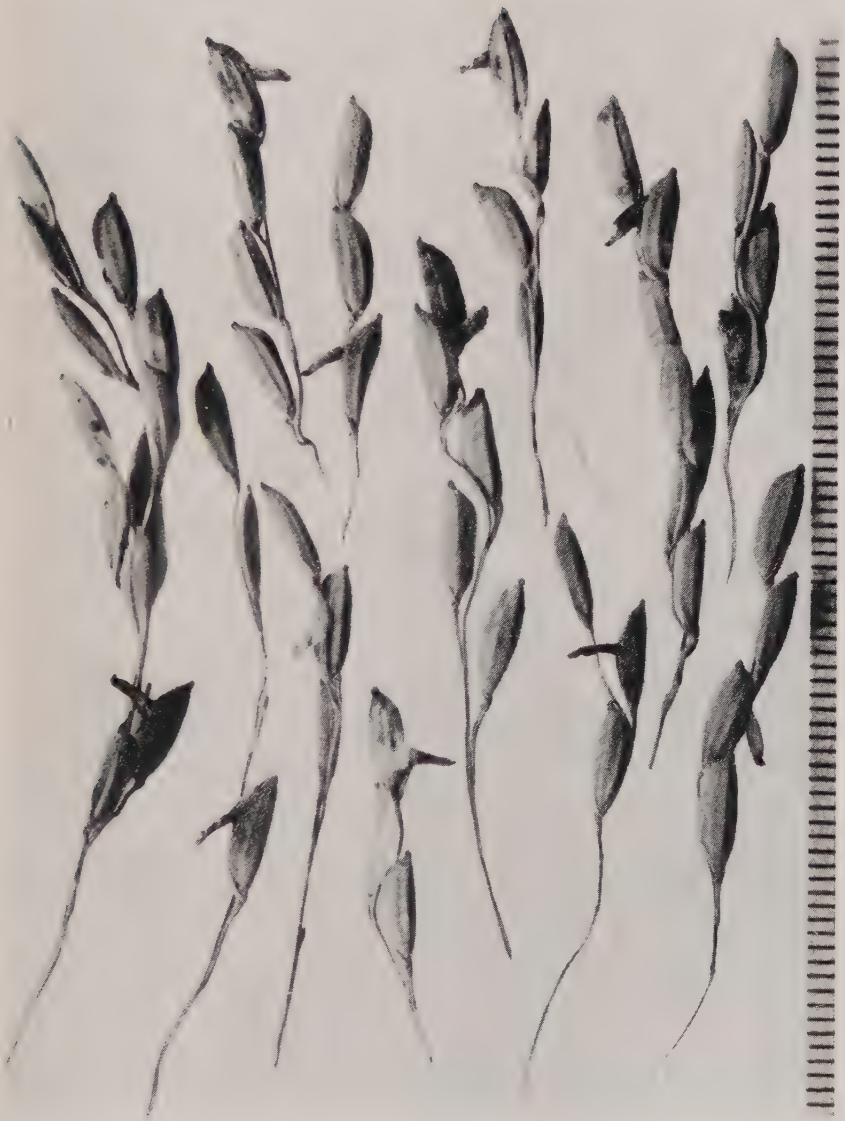

PLATE 10.

PLATE 11.

PLATE 12.

PLATE 13.

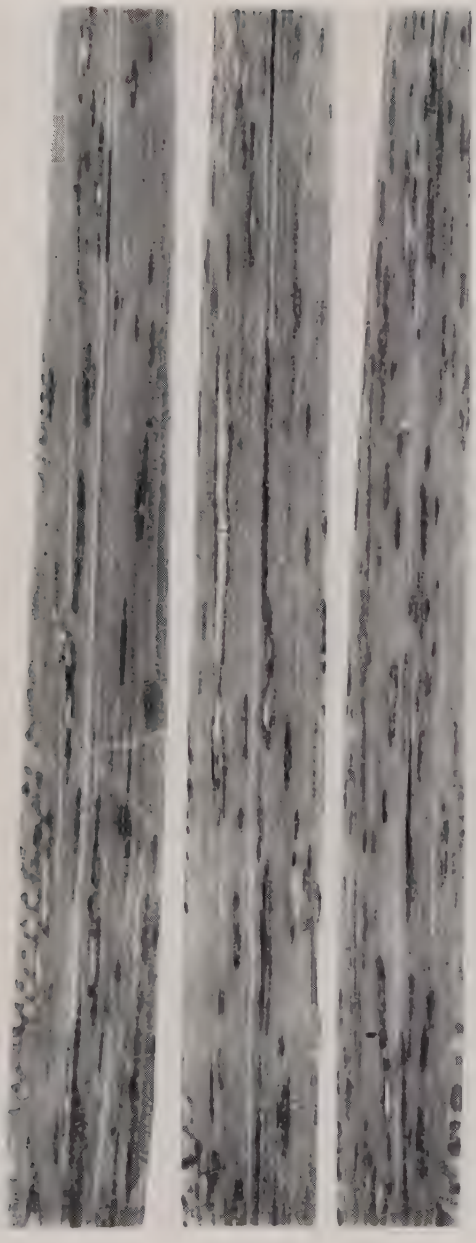

PLATE 14.

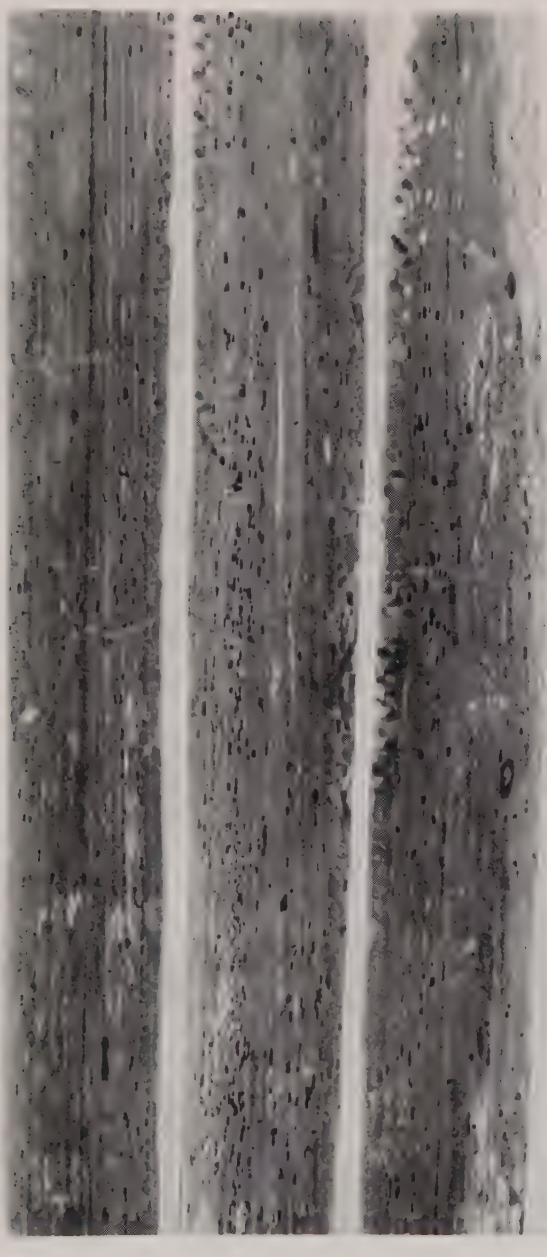

PLATE 15.

ERRATA

PROGRESS REPORT OF CABBAGE EXPERIMENTS AT BAGUIO, MOUNTAIN PROVINCE, by M. E. Gutierrez, Vol. 9, No. 1:

Pages 83 and 84, Table 1, Page 88, Table 2, Page 91, Table 3, Pages 95 and 96, Table 4, Page 101, Table 6,	Read ± instead of +, between the set of figures in every column opposite "Average per bed"

Page 101, Table 6, column 1, line 9. Read *65.276* instead of *65,276*.

37331—7

BUREAU OF PLANT INDUSTRY

AGRICULTURAL STATIONS AND SEED FARMS

1. Central Experiment Station, Manila
2. Lamao Horticultural Station, Limay, Bataan
3. Lipa Citrus-Coffee Station, Lipa, Batangas
4. Gandara Seed Farm, Gandara, Samar
5. Baguio Plant Industry Experiment Station, Baguio
6. Maligaya Rice Station, Muñoz, Nueva Ecija
7. Ilagan Tobacco Station, Ilagan, Isabela
8. Maridagao Rubber Station, Pikit, Cotabato
9. Los Baños Economic Garden, Los Baños, Laguna
10. Guinobatan Abaca Experiment Station, Guinobatan, Albay

SUBSTATIONS

1. Davao Seed Farm, Davao Penal Colony, Davao
2. Kidapawan Tobacco Substation, Cotabato
3. Abuyog Abaca Substation, Abuyog, Leyte

RESERVATIONS

1. Halcon Rubber Substation, Baco, Mindoro
2. Gingoog Lanzon Reservation, Gingoog, Oriental Misamis
3. Abaca Disease Station, Kapatalan, Siniloan, Laguna
4. Quisolon Reservation, Bukidnon
5. Bansalan Reservation, Davao

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